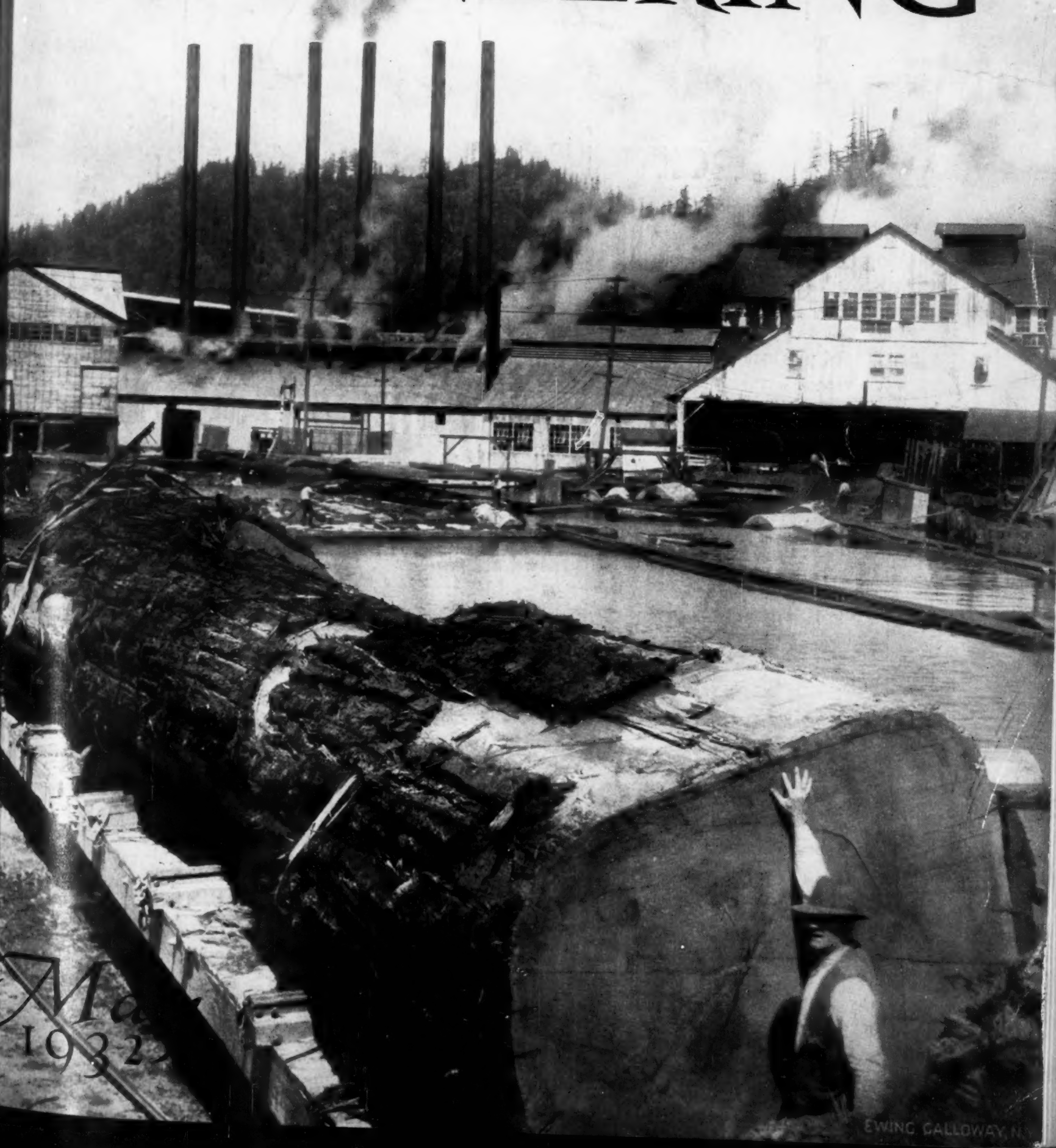
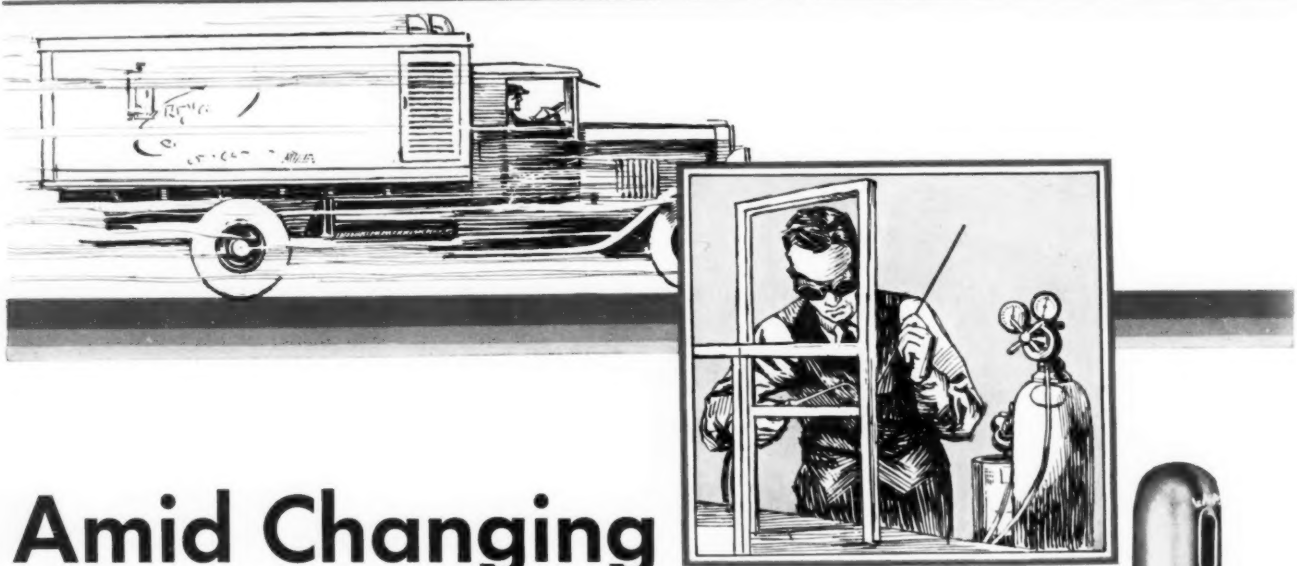
MECHANICAL ENGINEERING





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MECHANICAL ENGINEERING

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WHAT IT'S ALL ABOUT

CHOOSING cover pictures for MECHANICAL ENGINEERING is fraught with all sorts of interesting possibilities. Last month's cover, for example, showed a hydroelectric plant. We spoke of it quite casually as representing one of the competitors of coal, as its appropriateness lay in an article under that title which summarized some papers read at the Bituminous Coal Conference held in Pittsburgh. The picture was, of course, symbolic of all hydroelectric plants. Any other plant would have served. But naturally every one wanted to know what plant we had used. The picture showed the Long Lake plant of the Washington Water Power Company on the Spokane River.

Our cover for March also caused comment. It showed a milling-machine operator looking intently at his work. What we hoped to convey was the idea that some of the articles in the March issue discussed the problem of men and machines. Simple enough, so it seemed. Some got the idea and liked it—said that at last MECHANICAL ENGINEERING was beginning to take note of the human element—others did not understand or didn't like it.

THIS month we have made no attempt to be subtle or obscure. The picture on the cover has nothing to do with anything inside. It is, according to the photographer, the sawmill at Bull Creek Flat on the Redwood Highway in northern California.

The A.S.M.E. has a very active Division devoted to the Wood Industries. We hope members of the Division will like the picture as much as we do. The more than twenty thousand readers of MECHANICAL ENGINEERING must have many pictures that would make suitable covers or frontispieces. We can't use twenty thousand, but a few of the best would help us to tap new sources of material, and the others would give us an idea of the kinds of pictures our readers are interested in.

BOOK reviews and correspondence pile up so that we have sometimes threatened to run a special issue devoted almost exclusively to them. Many of these books and letters deal with the perplexing social and economic problems that are demanding such serious attention from every one these days.

Last month we asked Ralph E. Flanders to review Charles Whiting Baker's "Pathways Back to Prosperity," and in accepting the commission he said he wished to consider at the same time Harper Leech's "The Paradox of Plenty," and Arthur Dahlberg's "Jobs, Machines, and Capitalism;" three books, as he put it, that formed an "ascending trilogy." Under the title "Required Reading," the reviews of the three books are worked together to form our leading article this month. Because of their engineering backgrounds, Messrs. Baker and Dahlberg especially should appeal to engineers.

RECENT changes in the registration laws for professional engineers in New York State which look to more rigid requirements and enforcement, follow closely upon a resolution adopted by the Council of The American Society of Mechanical Engineers at the Annual Meeting last December, accepting state registration of professional engineers as an existing fact, placing itself on record as being ready to cooperate with other engineering societies "to the end that a draft of a uniform registration law may be adopted for use as a model by state governments," and maintaining the position that "neither in practice nor for the purpose of registration can professional engineers be divided into classes with respect to the various so-called branches of engineering."

It has seemed desirable, therefore, to bring up to date the analysis of state laws on engineer registration that appeared in the March, 1930, issue of MECHANICAL ENGINEERING. Accordingly, Blake R. Van Leer, Assistant Secretary, American Engineering Council, prepared such an analysis for this issue. A feature of Mr. Van Leer's analysis is a table of the requirements of the 27 states having engineer registration requirements in which are given the names and addresses of the officials who may be consulted regarding further details. Statistics show that while approximately two-thirds of the population of this country live under registration laws, not more than one in five reported in the 1930 census as engineers are registered.

LAST month Herbert N. Eaton discussed the national hydraulic laboratory at the Bureau of Standards from the point of view of explaining why the particular design chosen was decided upon. This month he describes the new building itself, giving detailed descriptions of the supply and measuring basins, the main flume, and the discharge tanks. The laboratory building provides facilities for research on numerous projects and problems connected with hydraulics and hydraulic structures and machinery. We are confident that it will become the instrumentality through which notable contributions to engineering knowledge will develop.

IN HIS "English and American Tool Builders" Joseph W. Roe shows how it was necessary to develop the machine tool in order to build the machinery which the industrial revolution demanded. Watt's difficulties in boring cylinders for his steam engines are well known

to students of his life and times. Discouraging limitations confronted him and his contemporaries on every side. Their tools were hopelessly inadequate to make what their inventions called for. Side by side there went on, and ever since has been going on, in consequence of this condition, the simultaneous development of the tool and the machine. Ideas in men's brains and designs on drafting boards must be translated into enduring materials so accurately and cleverly worked that the machines they represent may actually perform the functions for which they are designed.

This skill and ingenuity of the early mechanics and designers provided the means by which, starting with hand tools and hand-tool methods, machine tools were built which became increasingly effective and accurate. Here is represented an intelligently controlled evolution in which simple and inaccurate machines were used to make more complex and more accurate ones, fresh triumphs resulting from every well-planned and carefully executed effort of designers and workmen toward the desired end. The story of the development is a fascinating one.

ONE of the shops in this country in which these evolutionary developments took place was that of Brown and Sharpe, of Providence. In reminiscent mood Luther D. Burlingame of that company, addressing the Cincinnati Section of the A.S.M.E., showed how machine tools had conquered the "thousandth of an inch and the second of time." Mr. Burlingame's story, published in slightly abbreviated form in this month's MECHANICAL ENGINEERING, is naturally concerned chiefly with those phases of this development that went on in the Brown and Sharpe shop. To the designer or mechanic who has modern machine tools and measuring devices to work with and who realizes how greatly the success of his work depends upon the degree of precision upon which he can rely, the story of the efforts to provide this accuracy will serve as a reminder of his debt to all those who have made it possible.

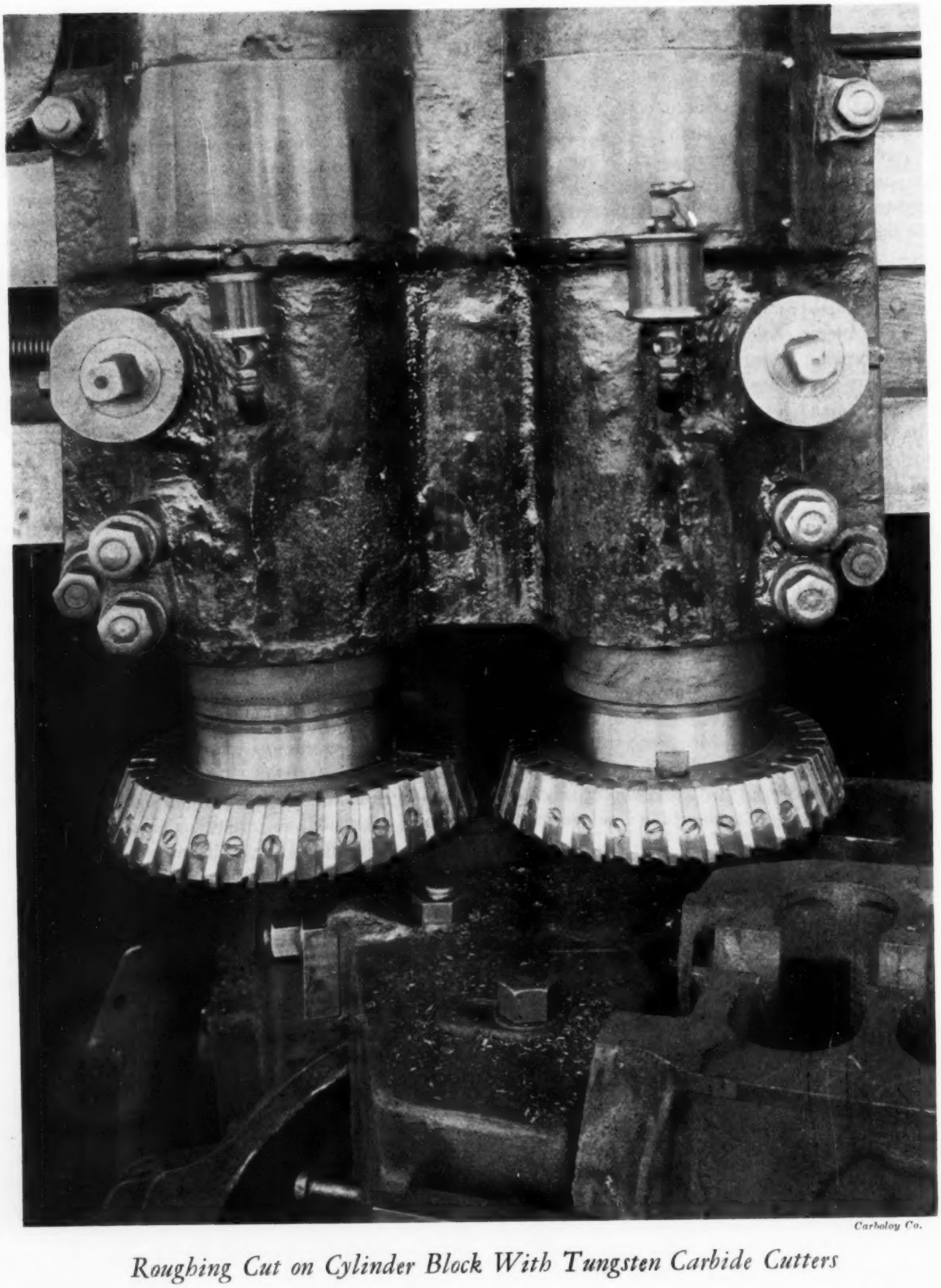
HEREDITY as a factor in evolution has its limitations. Sometimes it is fatal and a species becomes extinct because it can no longer continue to adapt itself to changed environment with so many handicaps in the form of inherited characteristics that are no longer useful. There was once a great race of dinosaurs roaming the earth—lords of creation, from all indications. If these giant reptiles ever pondered their place in the scheme of things, they undoubtedly reasoned that they represented the ultimate in organic evolution. What could surpass their sleek and streamlined bulk, their unprecedented physical power, their offensive and defensive equipment? But time passed them by and they left only their footprints in the prehistoric sands and the bones that testify to their gigantic size in the waste heaps of the past. As conditions changed they were much too definitely dinosaurs to persist far into the future for which the specifications for survival were different and rigid.

THE limitations of acquired characteristics dog man's efforts in his mechanical designs. To build an automobile like a carriage without a horse but with a whip socket was natural enough to a generation that thought of automobiles as horseless carriages and that had no other forms to copy. Development of automobile design soon eliminated the whip socket. Designers began to ask themselves what they wanted to accomplish and how best to do it. When designers are free from the entangling traditions of the past that retard their progress, when they have overcome the inertia of precedent and use the past as a springboard into the future, they are likely to make rapid progress.

A. L. DE LEEUW is a designer who goes back to fundamentals. When he considers the design of a machine tool he does not ask himself how such a machine tool has been designed in the past, but what is the best way of accomplishing the object he has in mind. He analyzes his problem thoroughly, and then goes to work.

Knowing this characteristic of Mr. De Leeuw's, we asked him to tell readers of MECHANICAL ENGINEERING how he would go about designing machine tools for using the newer cutting-tool materials, such as tungsten and tantalum carbide. Mr. De Leeuw has responded with enthusiasm this month. He discusses the problems of vibration, so important in machine tools. He treats specifically of the problems presented by the lathe, the boring-machine, planers, and shapers.

AFTER reading Mr. DeLeeuw's article you will be convinced of the logic and lucidity of his writing. Mr. De Leeuw's friends have long known that he had this rare ability to express himself in simple, clear, and interesting language. Others are finding this out. Whittlesey House has just published Mr. De Leeuw's book "Rambling Through Science." Perhaps you understand relativity, light, atoms, electrons, probability, the quantum theory, and a host of other things fundamental to science. But most folks do not, and your children and non-engineering friends probably do not. Mr. De Leeuw writes most entertainingly and instructively about these things in every-day terms that make you feel that they are not so mysterious after all. Locomotive whistles, spiders, bowling balls, slot machines, gambling, provide Mr. De Leeuw with points of departure for his illuminating explanations, which he presents in a stimulating conversational style that make easy but profitable reading.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Roughing Cut on Cylinder Block With Tungsten Carbide Cutters

"REQUIRED READING"

Three Surveys of the Existing Economic Disorder

By RALPH E. FLANDERS[1]

THERE is forming at this moment, in the United States, a consistent body of analysis and conclusions as to the causes of and remedies for our economic muddle. The degree of self-consistency which it shows is all the more remarkable when we consider that it arises simultaneously from widely scattered sources. It finds expression in unpublished manuscripts, in personal letters, in magazine articles, in papers read before society meetings, and in books. To this group belong such articles as Professor Fairchild's on "The Fallacy of Profits" (unduly stressing the negative side) in the February *Harper's*, and the paper on "The Economic Aspects of Stabilization" by Virgil Jordan in the January number of Mechanical Engineering. These are by way of example only. Now we have before us the three books listed below; and they, too, are by way of example. Others have been published, and there are doubtless still others on the press and more yet in manuscript form.

Pathways Back to Prosperity. By Charles Whiting Baker. Funk & Wagnalls Co., New York and London, 1932. Cloth, $5^1/_2 \times 8^1/_4$ in., xix + 351 pp., tables. $2.50.

The Paradox of Plenty. By Harper Leech. Whittlesey House, New York and London, 1932. Cloth, $5^3/_4 \times 8^1/_2$ in., xviii + 203 pp., $2.50.

Jobs, Machines, and Capitalism. By Arthur Dahlberg. The Macmillan Co., New York, 1932. Cloth, $5^1/_2 \times 8$ in., xviii + 252 pp., with tables and diagrams, and folded chart in cover pocket. $3.

One aspect of this group of ideas was outlined by the writer in an article "Engineering, Investment, and Social Well-Being," which appeared on page 254 of the April number of this journal. The presentation was incomplete, however; and the most important of the omitted factors is ably presented in Mr. Baker's book. He is known to very many engineers, having been a vice-president of The American Society of Mechanical Engineers, and formerly and for many years editor of *Engineering News*.

PATHWAYS BACK TO PROSPERITY

Mr. Baker's contribution lies in raising the question as to whether we are "approaching the end of the great construction era," to put the matter in his own words. The immediate and instinctive reaction of the engineer to such a question is one of violent dissent. As a profession we are devoted to progress. We are not inclined to question its continuance along familiar lines. If for several generations there have appeared a series of inventions whose manufacture has required the building of great workshops and elaborate equipment, why should not the process continue for an indefinite number of future generations? If billions of investment for many decades have been poured into shipbuilding, and into canal and railroad building, why should the development cease?

Some of the factors which act in the direction of slower progress for this country are clear. We have restricted immigration, and the natural population increase is slowing up. This requirement for industrial expansion will be a diminishing one for the future. We have railroads enough for our present needs. There will be new industries a plenty, but equipping them in the ordinary course will not require an enormous aggregate of expenditure, unless some major development like the automobile appears. The new industries of radio and rayon, for instance, were equipped to supply a nation at a relatively inconsiderable cost, such is the productive capacity of our machinery. Finally, in all the established industries the productive capacity is far greater than any demand that has ever been put upon it.

It is easy to deny this situation, as it is easy to overstate it; but when we remember what a large share of the improvement in production in the last decade has come from advanced management policies, which involve very small capital outlays; and when we note the continuing absence of that hoped-for major new development which shall energize the return to prosperity, we are justified in pausing for thought. Continuing advance is not in question; but it is doubtful if that advance will be of a kind to absorb in new investment the profits from our present equipment when business is good.

The remedies proposed are put by Mr. Baker in the mouth of a convenient visiting Martian, and consist of such measures as shorter working hours, readjustment of building-trade wages to stimulate house building, acceptance of a smaller profit level from business operations, the transfer to the state of title to certain forms of natural wealth, lower prices for goods, etc., etc.

Where Mr. Baker fails, in this reviewer's judgment, is in the assumption that for some reason we must "say good-by to extravagance, public and private," and find ways whereby a return to simpler modes of living can be made. This idea recurs in the book again and again. Why lessen our consumption of goods? If capital expenditure is not so necessary as formerly, why not divert unneeded energies into desirable consumption, private and public? Why label our enjoyment with the opprobrious tag "extravagance?" Why not build up the consuming capacity of that great mass of our population which is now and always has been condemned to "simpler modes of living?" Mr. Baker, like the reviewer, was

[1] Springfield, Vt.

born in Vermont, where the doctrines drilled into our childhood were those of the two great Calvins, John Calvin and Calvin Coolidge. But do they now apply?

THE PARADOX OF PLENTY

To these questions Mr. Leech's book gives unhesitating and enthusiastic reply. We are living in the age of plenty. Our economics, our financial doctrines, our business morals are still based on the experiences of ancient and bygone ages of famine. In these outmoded ideas and our persistence in them, lie the causes of our present discomfiture. This clinging to outworn ideas is as true of Socialism and Karl Marx, as of Capitalism and Adam Smith. In Mr. Leech's view, the significant element in modern life is the abundant provision of power—steam, electrical, internal-combustion, but especially electrical. He exalts this as against the achievements of science, invention, and engineering, as though modern power came "by chance" as he says! He alludes only in passing to that "transfer of skill" which, as Dean Kimball has shown, is the heart of the effectiveness of modern mechanism. Mr. Leech has a grouch against the overrated engineer. But this, however annoying, is a minor defect in a first-class book.

Every chapter, every paragraph, is stimulating—sometimes disconcerting. Particularly so is his Chapter I, entitled "The Peril of Plenty," in which he forcefully outlines the group of ideas mentioned at the beginning of this review. The wealth of Dives, he insists, depends on the ability of Lazarus to buy his output.

On the subject of waste (the engineer's pet preoccupation) he has this to say:

> In recent years, officials of the United States Department of Commerce, who have been loudest in denunciation of the wastes of distribution and most active in broaching plans for eliminating it, when discussing the displacement of men by machinery in productive industries have recited with gratification the growth of all sorts of new occupations which have provided work for those displaced from primary industries.
>
> The growth of recreational jobs, the increase in the number of barbers, bond salesmen, policemen, hotel employees, and beauty-parlor attendants have all been hailed with joy as offsetting the decline in the number of farmers, railroad men, and mill hands.
>
> Such statements of political and industrial leaders have been unconscious admissions that, under our existing financial organization and trade set-up, no wastes which tend to prevent underconsumption and lessened buying power can be safely done away with. It is another phase of the peril of plenty and of Dives' dilemma.

Of the function of savings he says:

> Abstention and savings become of ever-decreasing importance in the creation or accumulation of wealth, with the result that the whole complex of emotions and doctrines which identifies capital or the tools of production with the fruits of abstention and saving is becoming a bundle of dangerous anachronisms.

On the subject of profits he delivers himself thus:

> Wall Street rejoices at reports of mounting corporation profits, but excessive profits are the certain forerunner of the decline of capital values.
>
> Prosperity is the fruit of the quest for profits; depression is the result of their too great realization.
>
> Naturally it is difficult for the banking mind, saturated with the tradition of wealth creation by saving—which comes from the era of seedtime and harvest—to grasp this aspect of the age.

Chapter V is a purely gratuitous glorification of the "Man of Prey" as against the engineer and organizer. Here Mr. Leech has slipped back into the generations just past, in which society was advancing into new territories, new resources, and new techniques. The viewpoint is inapplicable to the days ahead. He is perhaps uninformed of the successful competition of management engineering with the old-fashioned business privateer. The American Telephone and Telegraph Company, whose practices he mentions approvingly, has a management preeminently of the engineering type.

In general, Mr. Leech does not give remedies, he offers prophecies. He looks for a diffusion of our business and industrial life over the countryside, following the transmission lines. The metropolis is not to grow further at the expense of the country, but may improve in quality, if not in size. International trade and finance will become of steadily lessening relative importance. Finally, in a world freed of scarcity values, he looks for a new social note—a "new generation free and unafraid."

This book must be read. Your ideas will be shaken up They will at least be freed from dust. Perhaps they will be rearranged.

JOBS, MACHINES, AND CAPITALISM

Not being an engineer, or sympathetic to engineering, Mr. Leech does not (as has been indicated) concern himself with control. He is a spectator and prophet. No engineer is content with these roles. He requires action. It is perhaps his engineering training which leads Mr. Dahlberg in our last book to apply himself directly to remedial action.

His book is a fascinating one. We are again asked to face the immense productivity of our resources and our technology. Again, also, we are asked to believe that the wastes of modern distribution are a complementary effect of the efficiency of production. They represent on one hand the frantic endeavor of those displaced by machinery to reinstate themselves through the medium of gas stations, door-to-door selling, etc.; and on the other hand, the equally desperate endeavor of business to dispose of products which do not sell themselves, to purchasers who do not want them or cannot afford them. In Mr. Dahlberg's analysis there is the same emphasis as in those of the other authors on the search for investment by those receiving large incomes who cannot or do not wish to spend all they receive. There is the added distinction between "goods spontaneously demanded"—food, clothing, shelter, etc.—which can be disposed of in limited amounts to every human being who has the price, and goods not spontaneously demanded, for the disposal of which the rich are pursued with every artifice of salesmanship.

Mr. Dahlberg has devised a most elaborate and ingenious chart of the whole flow of raw materials, labor energy, finished products, purchasing power, and social culture, based on a hydraulic analogy. Tanks, pumps, motors, throttle valves, flow meters, distributing valves, automatic control mechanisms of all sorts, simulate the actual play of materials and forces in the social mecha-

nism, even to expenditure for propaganda to maintain the system! He believes that in this chart form he has found a new language for presenting three-dimensional economic facts, and that its use and development will lead to conclusions which are beyond the reach of verbal reasoning and presentation. To the reviewer, this claim seems doubtful. The chart already approaches the limit of complication which can be easily comprehended, in spite of the fact that Mr. Dahlberg has omitted the circuit showing the flow of population. He has also disregarded the elasticity in volume of currency and credit, which is of great actual importance, and which, if adequately represented, would have greatly multiplied the intricacy. Finally, the conclusions to which he comes have, in general, been reached by others without employing his particular device. Such, for instance, is his conclusion as to the sterility of many financial processes which operate under the respectable name of "investment."

The conclusion to which Mr. Dahlberg's studies have led him is that the most hopeful device for restoring the balance between production and purchasing power would be country-wide shortening of labor hours by act of Congress. He does not consider the constitutional difficulty a serious one. He believes that such action would distribute present employment and, by generating an artificial scarcity of labor, give to it bargaining power which would result in that redistribution of the flow of wealth which is necessary for the survival of our present system.

All this is enough to send chills up and down the spine of the business man; but the alternatives are worse yet, and he shows how it is to the ultimate advantage of one class after another to make the change. In one respect he would appear to be overplaying his hand. With his shorter hours he looks for largely increased power for the trade unions. In saying that shorter hours will strengthen the unions, is not our author in effect saying that their power increases as it becomes less needed? The converse of this, that they are most ineffective where most needed, has been a standing criticism by their enemies. Our rightful expectation is that union labor will join with the other elements of society in movements which are evidently for the social good, for the sake of the good itself.

These and other minor criticisms occur. But don't let them deter a single reader. Buy the book and study it!

The net effect on the reviewer of these three books was to confirm him in the growing belief that we are approaching, or are in, a situation new to human history; that the new possibilities are intrinsically desirable to a degree we can scarcely estimate; and that the best practical means of attaining them seem to lie along the line of shortening labor hours and diverting uninvestable savings (by taxation or otherwise) to desirable public expenditures.


EWING GALLOWAY N.Y.

"THE REQUIREMENT FOR INDUSTRIAL EXPANSION WILL BE A DIMINISHING ONE IN THE FUTURE . . . . IN ALL THE ESTABLISHED INDUSTRIES THE PRODUCTIVE CAPACITY IS FAR GREATER THAN ANY DEMAND THAT HAS EVER BEEN PUT UPON IT"

ENGINEER REGISTRATION LAWS

Their Status at the Present Time

By BLAKE R. VAN LEER[1]

IN THE March, 1930, issue of MECHANICAL ENGINEERING there appeared a detailed analysis of the state laws on Engineer Registration. Two years have elapsed since, and during that time mechanical engineers have evinced a considerable interest in the subject. This is especially indicated by the recent action of the A.S.M.E. Council, which adopted, on December 4, 1931, upon the recommendation of a Special Committee on Registration of Engineers composed of John H. Lawrence, Chairman, Dexter S. Kimball, Paul Doty, C. F. Hirshfeld, Virgil M. Palmer, and James M. Todd, the following resolution:

. . . that The American Society of Mechanical Engineers accept state registration of professional engineers as an existing fact; that for this reason it place itself on record to that effect and that it cooperate officially with other engineering societies to the end that a draft of a uniform registration law may be adopted for use as a model by state governments in the preparation of engineering registration laws and in the revision of existing laws; and that

The A.S.M.E. maintain the position that neither in practice nor for the purpose of registration can professional engineers be divided into classes with respect to the various so-called branches of engineering; and that

For the purpose of achieving these ends, the Chairman of the A.S.M.E. Committee on Registration of Engineers is hereby empowered to represent officially the A.S.M.E. in such cooperative efforts as are therein contemplated.

STATUS BEFORE ENGINEERING SOCIETIES

This interest was also made apparent by the request from The American Society of Mechanical Engineers that the American Engineering Council canvass its members and ascertain their views upon the subject of engineer registration laws. The American Engineering Council complied with The American Society of Mechanical Engineers' request, and in the fall of 1931 reported the following results:

FAVORABLE TO REGISTRATION OF ENGINEERS

National Societies:

American Institute of Consulting Engineers
American Society of Agricultural Engineers
American Society of Civil Engineers
The American Society of Mechanical Engineers

State Societies:

Colorado Engineering Council
Indiana Engineering Society
Iowa Engineering Society
Kansas Engineering Society

Local Societies:

Engineers' and Architects' Club of Louisville
Engineers' Club of St. Louis
Grand Rapids Engineers' Club
Little Rock Engineers' Club
Mohawk Valley Engineers' Club
Technical Club of Dallas
Topeka Engineers' Club

UNFAVORABLE TO REGISTRATION

National Societies:

American Institute of Chemical Engineers
Society of Industrial Engineers

State Societies:

None

Local Societies:

Engineering Society of York (Pa.)

DIVISION OF OPINION WITHIN SOCIETY

Local Societies:

Detroit Engineering Society
Duluth Engineers' Club
Engineers' Club of Cincinnati
Engineers' Society of Milwaukee

NO ATTITUDE EXPRESSED

National Societies:

American Institute of Electrical Engineers

State Societies:

Vermont Society of Engineers

Local Societies:

Engineers' Club of Columbus
Washington Society of Engineers

This indicates a predominance of opinion among the member organizations of the American Engineering Council in favor of registration. In fact, of the 60,000 professional engineers represented through the American Engineering Council, it would appear that over 38,000 are represented by societies in favor of registration, about 2000 by organizations opposed, and about 20,000 by organizations in which there is either a division of opinion or no expressed opinion upon the subject.

Those who desire details of the existing state laws on engineer registration should consult MECHANICAL ENGINEERING, March, 1930, pp. 215–218. If additional information is desired, a letter addressed to the Secretary of the Registration Board of Engineers in the capital city of each state having a registration law, will bring a prompt response to specific inquiries. In the last two years, California, New York, and Wisconsin have amended their laws, and Kansas has passed a new law. The Oregon state legislature attempted to amend the Oregon law, but the amendment was vetoed. Bills requiring engineer registration have also been passed in the last two years by the legislatures of Ohio and Washington, but were vetoed by the governors. The Ohio law was vetoed because it permitted the licensing of corporations and partnerships, and the Washington law because it was too drastic. Wisconsin amended in 1931 its law for architects to include registration for civil engineers. This amendment defines civil engineering as follows:

(*c*) The practice of civil engineering, as covered by this section, embraces engineering investigation, design or responsible supervision of the construction and alteration of bridges, structures and buildings

[1] Assistant Secretary, American Engineering Council, Washington, D. C. Mem. A.S.M.E.

TABLE 1 REGISTRATION OF ENGINEERS AND REGISTRATION-LAW REQUIREMENTS

	Registration of Engineers, 1930 Status				Registration-Law Requirements				
					Years Experience Required		Fees		
State	Total state population, 1930 census	Total number of engineers, 1930 census	Total number of registered engineers	Total number of individual engineers holding membership in an engineering society (1929)	(a) If not a graduate of an approved technical university	(b) If a graduate of an approved technical university	Total registration	Yearly renewal	Secretary of board or corresponding official, name and address
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1. Arizona	435,573	1,256	392	659	6	2	$15	$ 5	V. O. Wallingford, P. O. Box 1035, Phoenix
2. Arkansas	1,854,482	948	232	283	4 [1]	2	15	15	M. Z. Bair, State Capitol Bldg., Little Rock
3. California	5,677,251	...	4,901	7,479	6	2	25	5	Albert Givan, Dept. of Professional & Vocational Standards, Sacramento
4. Colorado	1,035,791	1,456	429	1,193	7	3	15	5	M. C. Hinderlider, Capitol Bldg., Denver
5. Florida	1,468,211	1,573	766	788	3	0	25	5	A. D. Stevens, 208 E. Forsyth St., Jacksonville
6. Idaho	445,032	341	348	302	6	0	25	2	Emmitt Pfost, Commissioner of Law Enforcement, Boise
7. Illinois	7,630,654	18,010	955	9,731	6 [1]	4	15	1	M. F. Walsh,[3] Dept. of Registration & Education, Springfield
8. Indiana	3,238,503	1,666	1,132	1,935	10	4	25	5	Mrs. I. G. Belser, State Capitol Bldg., Indianapolis
9. Iowa	2,470,939	1,494	1,163	942	6	2	25	2	Ralph E. Kittinger, State House, Des Moines
10. Kansas	1,880,999	1,231	...	880	10	4	..	..	R. J. Paulette, 448 South 8th St., Salina
11. Louisiana	2,101,593	1,276	479	849	0 [2]	0	25	3	C. C. Sandoz, 815 Audubon Bldg., New Orleans
12. Michigan	4,842,325	10,566	1,257	5,166	6	2	20	5	C. T. Olmsted, 1043 Book Bldg., Detroit
13. Minnesota	2,563,953	1,818	488	1,832	6	2	25	5	W. W. Tyrie, 605 New York Bldg., St. Paul
14. Mississippi	2,009,821	641	191	183	6	1	25	10	T. G. Gladney, Box 466, University
15. New Jersey	4,041,334	16,512	2,743	6,495	6 [1]	4	25	1	Hugh A. Kelly, 710 Trust Co. of N. J. Bldg., Jersey City
16. New Mexico	423,317	513	332	172	0	0	5	..	Herbert W. Yeo,[3] P. O. Box 1079, Santa Fe
17. New York	12,588,066	...	9,300	21,129	8	4	25	1	Roy G. Finch, 112 State St., Albany
18. North Carolina	3,170,276	1,208	409	674	5	0	25	5	C. L. Mann, State College Station, Raleigh
19. Oregon	953,786	1,395	729	719	6	2	15	3	A. B. Carter, 631 Ry. Exchange Bldg., Portland
20. Pennsylvania	9,631,350	...	2,968	12,885	10	2	20	1	F. L. Bitler, 1103 Market St., Philadelphia
21. South Carolina	1,738,765	636	222	177	4	0	25	5	T. Keith Legare, P. O. Box 264, Columbia
22. South Dakota	692,849	224	342	131	6	2	25	5	Geo. C. Hugill, 367 Boyce-Greeley Bldg., Sioux Falls
23. Tennessee	2,616,556	1,559	399	904	4	0	25	5	Joseph W. Holman, 702 Stahlman Bldg., Nashville
24. Virginia	2,421,851	1,440	306	933	4	0	25	5	C. G. Massie, 4030 Fort Ave., Lynchburg
25. West Virginia	1,729,205	1,292	398	826	7	3	20	5	Geo. E. Taylor, 611 Bank of Commerce Bldg., Charleston
26. Wisconsin	2,939,006	2,909	...	2,236	7	3	15	5 [4]	Arthur Peabody, State Architect, Madison
27. Wyoming	225,565	244	149	111	8	4	15	5 [4]	John A. Whiting, State Engineer's Office, Cheyenne
Total	80,827,053								
Total for U. S.	122,775,046; 65.9 per cent of population living under registration laws.								
Totals for 22 states having complete data		66,068	13,861						

[1] Graduation; 2 years' experience.
[2] Membership in or possessing qualifications required in one or more of American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers.
[3] Not a member of the National Council.
[4] Payable every two years.

directly connected with engineering work; such as railroads, hydroelectric plants, industrial plants and buildings or the structural members of other buildings, and other civil engineering works and projects, including publicly and privately owned public utilities, except the design of the electrical and mechanical equipment of such utilities.

The questions most frequently asked about engineer registration are the following: What states have registration laws? What are the basic requirements for registration? What are the fees? Are the laws effective? All of the questions except the last are answered in Table 1.

EFFECTIVENESS OF EXISTING LAWS

It is extremely difficult to ascertain specific facts as to the effectiveness of engineer registration laws. Conflicting reports are frequently heard. The fairest and most impartial reports usually contain the following explanation. In most registration laws, it is necessary to provide that all engineers engaged in practice at the time the law is enacted, may register. Such men are required, usually within one year, to present an affidavit to the effect that they were engaged in the practice of engineering prior to the passage of the law. Because of this so-called "Grandfather Clause," no startling improvements in the standards of the profession can be immediately effective until those who came in under that clause have died or retired. The advocates of registration, however, point out that while the laws require the granting of a license to those who were practicing before the law was passed, the license can be revoked if it is proved that the holder is guilty of "any gross negligence, incompetency, or misconduct," and there are cases on record where licenses have been revoked.

In addition to the states listed in Table 1, Hawaii, Philippines, and Porto Rico have engineer registration laws. Although a number of states have amended their laws since their original enactment, there is no record of a state's repealing or abandoning its law once it has been enacted.

THE UNITED STATES AS A WHOLE

Today, the twenty-seven states which have engineer registration laws embrace about 55 per cent of the area of the Union and more than 65 per cent of the population. It is also interesting to note (see Table 1) that although the 1930 Census showed 66,068 technical professional engineers in twenty-two states (complete data could not be obtained for five states) who claimed to be earning their living as professional engineers, these same states had registered only 13,861, or about one-fifth as many. This may be due to any one or all of the following reasons: (1) That a considerable number of persons who were not engineers told the Census enumerators that they were; (2) that some states exempt certain kinds of engineers; (3) that a considerable number of engineers are working for and under the direction of a registered engineer (which the laws almost universally permit without registration); or (4) that some self-styled engineers are evading the law.

UNIFORMITY

Uniformity in registration laws would be highly desirable and convenient to both the profession and the public, and considerable effort is being directed to that end. During the past two years several meetings participated in by the foremost engineering societies of the country have been held to treat with this subject. Out of these came a tentative Recommended Uniform Registration Law for Professional Engineers. This tentative draft was revised June 22, 1931, and again in September, 1931. It is still open to revision, but in its present form has been approved by about fifteen prominent engineering societies. Copies of the proposed Uniform Law may be secured by addressing the Secretary of The American Society of Mechanical Engineers.

A potent factor in the effort to secure uniformity of registration laws is the National Council of State Boards of Engineering Examiners. The objects of this organization are set forth in Section I of its Constitution as follows:

The purpose of this Council shall be to promote uniformity of practice in the administration of state registration laws for professional engineers and land surveyors, to establish and maintain a system of national qualifications for registration, to provide for reciprocal relations between state boards, and to foster any movements having for their aim the promotion of the public welfare through engineering registration and the improvement of professional standards.

Twenty-four of the 27 state boards of engineer examiners are members of this council, which was started in 1920. Its secretary is Mr. T. Keith Legare, Box 264, Columbia, South Carolina. Considerable progress has been made toward uniformity of engineer registration laws in spite of the fact that there is very little uniformity in state laws dealing with other subjects of common interest.

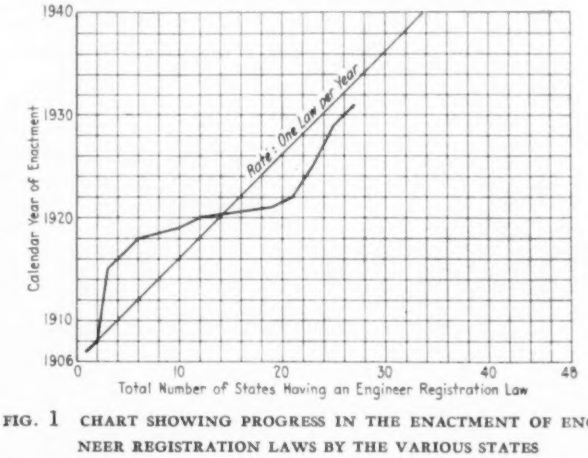

FIG. 1 CHART SHOWING PROGRESS IN THE ENACTMENT OF ENGINEER REGISTRATION LAWS BY THE VARIOUS STATES

(At the present rate it would appear that 1950 will be reached before all the states have enacted such laws.)

RECIPROCAL AGREEMENTS

The reciprocity clause in state engineer registration laws is an important one. The National Council of State Boards of Engineering Examiners has set up "Articles of Agreement on Reciprocal Registration" which have been subscribed to by its members, and in the past year it has taken steps to establish a National Bureau of Engineer Registration by the adoption in October, 1931, of the following report:

1 We agree that there should be a National Bureau of Engineering Registration, under the auspices of the National Council of State Boards of Engineering Examiners, to function as a fact-finding and certifying body.

2 This Bureau should eventually be self-supporting by means of fees received from applicants for certificates of qualification.

3 The office of this Bureau should be in some central location.

4 The Bureau should have a full-time paid Executive Secretary.

5 The purpose of the Bureau should be to investigate and verify the records of applicants and issue to those who fully comply with the standard requirements for registration adopted by the Council a "Certificate of Qualification," which may be used as evidence of qualification—for registration in those states agreeing to recognize said certificates, for membership in state and national engineering societies, for presentation to engineering colleges in connection with

(*Continued on page 375*)

MACHINE TOOLS:

The Conquerors of the Thousandth of an Inch and the Second of Time

By LUTHER D. BURLINGAME[1]

I CAN well remember when, before reaching my teens, I learned to read a micrometer gage brought home by my father, and how wonderful it seemed to friends and neighbors that measurements in thousandths of an inch could be accurately determined. This was before the one-inch micrometer had been brought out and indeed when it was difficult to produce lead screws of that length for micrometer calipers which would pass inspection within the required limit. An expedient made use of in those days was to make the longitudinal line on the barrel at an angle to correct errors of lead.

While expert mechanics had been able by means of the vernier caliper to determine thousandths for a period of years following 1850, when Joseph R. Brown brought out the pocket vernier caliper, yet, in the words of Mr. Halsey, it remained for the micrometer to make the use of thousandths "a commonplace;" and with modern developments this term can well be applied to micrometers reading to ten-thousandths, and hundred-thousandths are being recognized as actualities, while physicists now talk in millionths.

A difference between skilled mechanics of the early days and those of the present is that while the former often worked to very close measurements in making fits, depending on "feel" without knowing in decimals what the dimensions were, modern mechanics have to have a definite knowledge of the size as well as the relation in figures of one mating part to the other in order to determine tolerances and limits in interchangeable work, and to do this by gaging systems such that there will be general interchangeability, no matter in what factory produced.

MACHINE TOOLS AS FACTORS IN ACCURACY

The high degree of accuracy required in modern work is indicated by the fact that the machine tools used to produce gages must be of a higher degree of accuracy than the gages themselves, because of the tendency toward degradation in transferring accuracy. Master gages must be of a higher degree of accuracy than working gages, and the latter of a higher degree than the work itself, so that in order to make interchangeable work that will meet modern requirements, extreme accuracy of the machine tools used in the process is essential.

One of the important developments in recent years has been the transferring of accuracy from the workman to the tools so that high-grade work can be produced even by workmen of limited training and skill. An example of this is found in the production of accurate master lead screws, by use of which the commercial product is to be made.

Fifty years ago the Brown & Sharpe Manufacturing Company undertook the making of a special lathe for precision work in the commercial production of lead screws. William A. Rogers, who had been associated with the Pratt & Whitney Company in the development of the Rogers-Bond comparator, was also working on the problem of a precision screw. He asked Lucian Sharpe, of that firm, if he would undertake to grind a perfect cylinder. Mr. Sharpe's reply was very suggestive. He said:

> We are not making perfect mechanisms of any kind any longer in this establishment. A few years ago we felt competent to undertake perfect work of any and every kind, but we have grown wiser since then.

This struggle toward accuracy while realizing that perfection is unattainable, applied to making the master screw above referred to. The method followed was to take as good a screw as could be secured, carefully determine its inaccuracies, and correct these by the method shown in the Darling patent, Fig. 1. By oscillating the nut by means of the templet formed to correct the errors which had been found in the screw, a second screw made therefrom would be improved rather than be subject to the degradation previously mentioned. This better screw then being used as the lead screw, became the master, from which a still better screw resulted, the process being continued until the desired degree of accuracy was obtained—in this case such as to produce commercial work guaranteed within a variation not greater than 0.0004 in. per ft.

Previous to the use of this lathe, one with the best lead screw then obtainable had been reserved for precision work, and when it was discovered that because of wear and other variations a shortening in the lead resulted, it was found that by "jacking up" the center of the lathe the lead could be lengthened; and this was repeatedly done as the need arose, actually pulling the lag screws from the floor before the scheme was abandoned in favor of more permanently reliable methods.

LINEAR STANDARDS

The earliest precision machine for linear measurement produced in the Brown & Sharpe works was one (Fig. 2)

[1] Legal Technician, Brown & Sharpe Mfg. Co., Providence, R. I. Mem. A.S.M.E.

Presented at a meeting of the Cincinnati Section of the A.S.M.E., Cincinnati, Ohio, February 11, 1932.

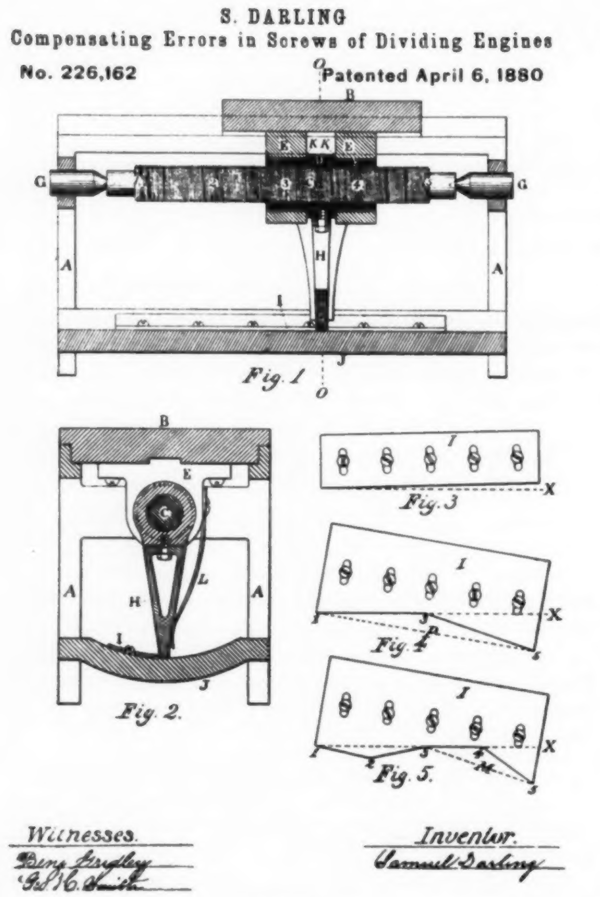

FIG. 1 CORRECTING DEVICE FOR PRODUCING MASTER SCREWS

designed by Oscar J. Beale in 1878. It employed a microscopic scale for setting the measuring nibs, and this scale had been compared in Washington to insure that it could be depended on for accuracy.

F. A. Halsey says of this machine:

> This was the first machine in which the authority of Whitworth as regards the superiority of end over line measures was disputed; and the line measure rehabilitated and placed where it belongs, as the ultimate standard.

It was because Whitworth plugs and rings which had been imported to be used as basic standards were found to be below the standard of accuracy to meet the requirements, that the Brown & Sharpe measuring machine was designed. This machine followed shortly after the comparator made by John E. Sweet, shown at the Centennial Exposition of 1876. The Sweet comparator, as I understand, was not a measuring machine in the sense that it determined original measurements as did the B. & S. machine, but compared one measurement with another.

The original B. & S. machine had provision for holding the work on centers not shown in the illustration. The vernier at the left reads to hundred-thousandths of an inch, while there is an adjustment at the right capable of even finer settings than the famous Whitworth millionth comparator, although perhaps these extreme refinements meant little at the time this machine was designed.

Since then, however, there have been developments in precision measurement so that greater refinements can be depended on and measurements repeated, but some of these refinements make the conditions very exacting, such, for example, as those affecting stability and temperature.

On a measuring machine used in the manufacture of gages and having a cast-iron bed 18 in. deep the pressure of a finger from below will spring the casting enough to allow a plug held between the measuring "nibs" to drop, and the same result follows laying the hand on the upper surface of the bed, the warmth of the hand expanding the casting.

SURFACE STANDARDS

For surface standards, such as surface plates, straight edges, etc., we have means for producing original standards by the three-plate method first suggested by Whitworth. This will produce plane surfaces to whatever degree of accuracy is desired, and can also be applied to the production of squares. As an example of the care in producing high-grade work shown by early mechanics, it is told of Samuel Darling, then at Bangor, Maine, that a visitor, holding two of Darling's straight edges up to the light, pointed out that a ray of light could be seen between them. Mr. Darling explained that he used woolen gloves when he handled such work in order that the warmth of his hands would not distort it.

An interesting test of surface plates was that of laying a large plate weighing 450 lb on the master plate, the friction being such that it took several men to move the upper one; then the surfaces were lubricated, and it was found that the heavy plate would float from its supporting plate when it was out of level but one one-thousandth of an inch in an inch.

During the World War, when large planers were required to produce lathes and other tools needed for munition work, The Amalgamated Machinery Company, of which Lucien I. Yeomans was a leading spirit, had a contract for manufacturing concrete planers with beds up to 184 ft in length, and the question was raised as to whether the curvature of the earth would have to be taken into consideration in leveling the ways of such planers. The question aroused much interest at the time, and it was found by calculation that if each portion of the bed were "level," the curvature of the surface would be such that the middle would be two and a half thousandths higher than the ends.

CIRCULAR SPACING

To secure accuracy in circular spacing, whether for graduating, index drilling, or gear cutting, may, like producing an accurate screw, mean starting with the best available divided wheel or plate, and through a series of corrections producing copies one after another, each being thereby improved, until the desired degree of accuracy is attained. These were all problems in accuracy toward the solution of which Joseph R. Brown

labored, and which were taken up where he laid them down and carried on by Oscar J. Beale. We can talk glibly about accuracy to a second of arc, but a little calculation shows this to be but 0.0004 in. in a radius of 21 in., which is less than a third of an inch in a mile.

APPLICATION OF PRECISION MEASUREMENTS

Henry M. Leland, who received much of his training in mechanical accuracy in association with Messrs. Brown and Beale, carried the methods learned from them to Detroit for the development of the Cadillac automobile, and so applied them that in the year 1910, when members of the A.S.M.E. were guests of the British Institution of Mechanical Engineers, he made a demonstration in London in which he disassembled three Cadillac cars, mixed the parts, and reassembled them at random, thus proving that the gaging system and the care in workmanship with which they had been produced made them interchangeable in fact as well as in theory.

The question of producing fits of the desired quality, such as those for cylindrical parts and for screw threads, has been receiving serious consideration in recent years.

A committee has already reported on a proposed series of fits for cylindrical parts, and this is now being further studied in regard to possible revision.

In the matter of screw threads, the National Screw Thread Commission has established certain types of fit, suited to widely varying needs. The ability to produce these fits commercially has been questioned, and samples of work from producers and users throughout the country have been secured, which are being measured in order to ascertain to what degree the prescribed tolerances and limits are being complied with.

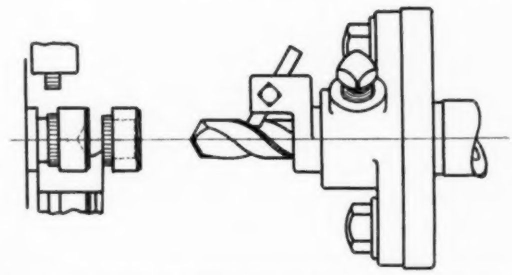

FIG. 3 OPERATING ON TWO BRASS SLEEVES SIMULTANEOUSLY IN A HIGH-SPEED SCREW MACHINE. TIME PER PIECE, $1^1/_3$ SEC

(Material, 0.638-in. brass rod; gross product per hour, 2700; spindle speed, 3600 rpm.)

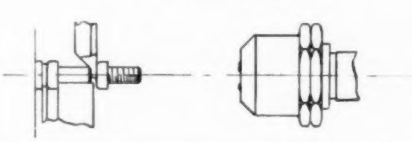

FIG. 4 BRASS SCREWS PRODUCED IN AUTOMATIC THREADING MACHINE AT THE RATE OF ONE PER SECOND, INCLUDING MILLING OF SLOT IN HEAD

(Material, brass; gross product per hour, 3600; machine-spindle speed, 5000 rpm backward; die-spindle speed, 7000 rpm backward.)

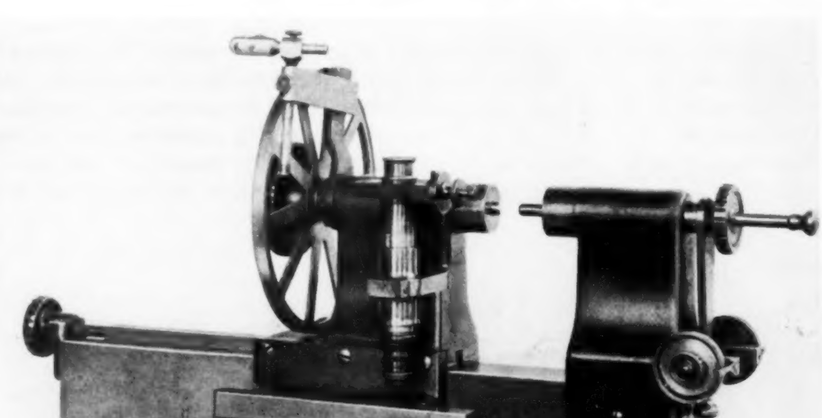

FIG. 2 EARLIEST PRECISION MACHINE FOR LINEAR MEASUREMENTS

INCREASING PRODUCTION

There are several factors involved in securing greater production from machines: namely, (1) increasing the cutting speeds and feeds; (2) simultaneous operations and operations on multiple pieces of work; (3) semi-automatic and automatic controls; and (4) reducing lost time in loading and between successive cuts. Important additional considerations, dependent upon the quantity of parts to be produced, are the setting-up time and the cost of special equipment, which latter, divided by the number of pieces produced, gives the cost per piece. In designing machine tools for both accuracy and speed this question of quickened production becomes vital.

MATERIAL AS A FACTOR IN SPEED

Following the analysis above given as applied to screw-machine work, the question of the material

operated upon becomes important. For example, brass, even though a much more expensive material than steel, can often be used, producing work at but a fraction of the cost which results when using steel, because of the higher cutting speed that can be employed. Thus a brass knurled-headed screw 3/4 in. in diameter and about 2 in. long can be made in one-quarter the time it would take to machine a steel screw of the same dimensions, and this more than offsets the difference in cost of material, so that the brass screw is not only cheaper but, as it takes only a quarter as much machine time, the machine is available for other work. In a drilled piece 9/16 in. in diameter and about 2 in. long, the time required, if the material is brass, is but one-seventh of what it is for steel, and the net cost, including the material, but one-third as much.

When, coupled with the speeding up, multiple simultaneous operations, or operations on more than one piece at a time, are possible, a further material saving of time can be effected.

The brass piece shown in Fig. 3 illustrates this. This piece, something over 5/8 in. in diameter, has operations performed on two pieces simultaneously, so that the time per piece in brass is 1 1/2 sec.

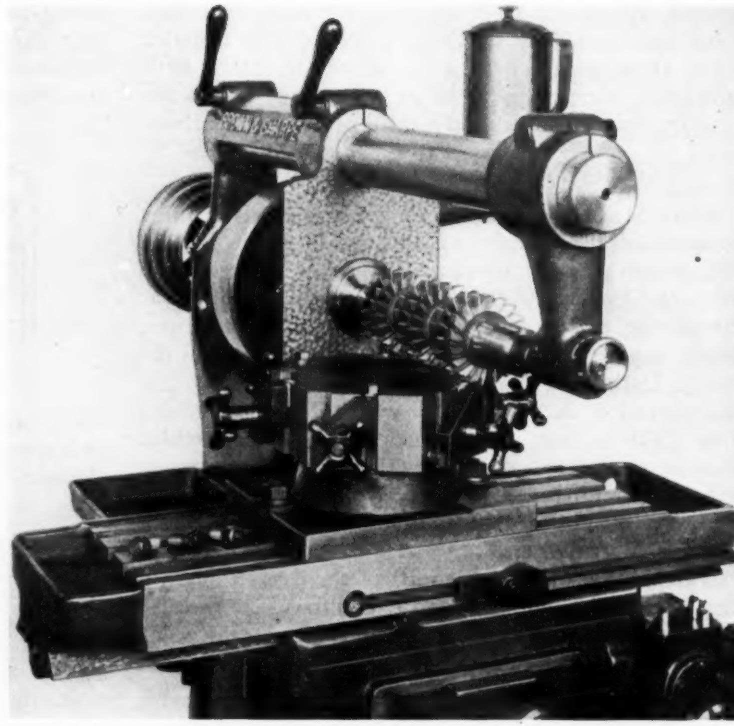

FIG. 6 MULTIPLE MILLING OPERATION ON HEXAGONAL HEADS OF BRASS SCREWS, USING INDEXING ATTACHMENT

To justify the concluding words of the title of this paper, "The Second of Time," a screw is shown in Fig. 4 which is produced at the rate of 3600 per hour or one a second. This includes the slotting of the head, which, by the use of a transfer arm, is done simultaneously with other operations.

I was challenged as to whether any milling operation could be found which required but a second of time. While under certain conditions such operations have been done as a "stunt" on a milling machine, here is one which is done well within the period of one second which is required to produce the completed screw, and

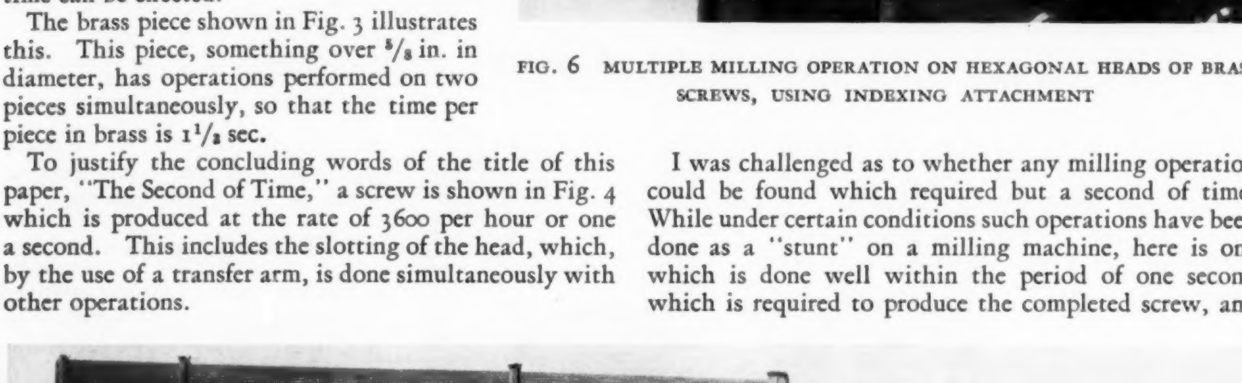

FIG. 5 MAGAZINE-FEED ATTACHMENT FOR AUTOMATIC SCREW MACHINE

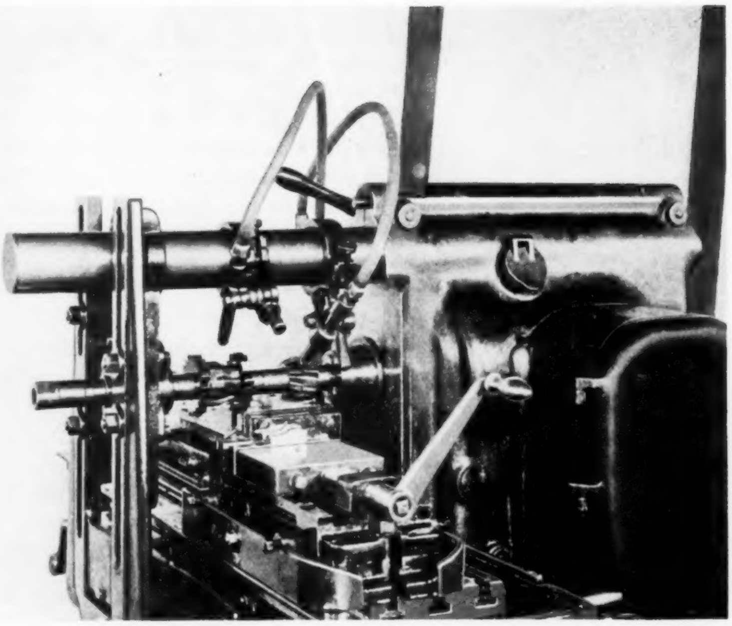

FIG. 7 MILLING BY THE RECIPROCATING METHOD

other screw-machine milling operations can be brought within this time.

When screw-machine work is produced at these high speeds, the bars of stock are used up so rapidly that an appreciable time is required to reload the machines and the attendant can care for but a limited number of the latter. This has led to the devising of a magazine feeding attachment such as that shown in Fig. 5. With this attachment, when a rod is used up the next one is brought automatically into the chuck, and production is continuous.

MULTIPLE MILLING OPERATIONS

The savings effected by operations on a number of pieces of work simultaneously are also possible in milling-machine work. An example where the $^5/_8$-in. flats for the hexagonal heads on brass screws are milled in multiple is shown in Fig. 6.

One piece is completed for each advance and return of table and the fixture indexed one position. In this case the reloading time is practically equal to the cutting time, so that the non-cutting time is reduced to a minimum. The net cutting time for each is 9 sec, or $1^1/_2$ sec per face milled. Compare this with what George E. Whitehead has recorded of his apprenticeship in the sixties, where he says that the heads of square- and hexagon-headed screws were planed held in index centers, and it was thought to be a great step forward in quantity production to make the screws in pairs with their heads adjoining, and cut them apart after planing.

Another example of reciprocal milling, shown in Fig. 7, illustrates the set-up of an automatic milling machine so that there are two sets of cutters mounted to cut in opposite directions and two vises mounted on the table to hold the work in different positions so that as the first cut is completed it is transferred to the second vise for the second cut, the spindle of the machine being automatically reversed to bring about the correct direction of cutting. The vises have vertical adjustment so that each can be independently adjusted to allow for the variation in diameter due to the grinding of its particular set of cutters.

Another method of reducing time between cuts is by the so-called "rotary" or "continuous" method. Such a method was brought out many years ago by the

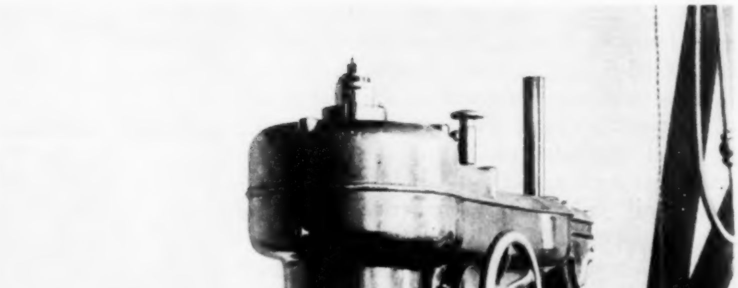

FIG. 8 CONTINUOUS ROTARY MILLING

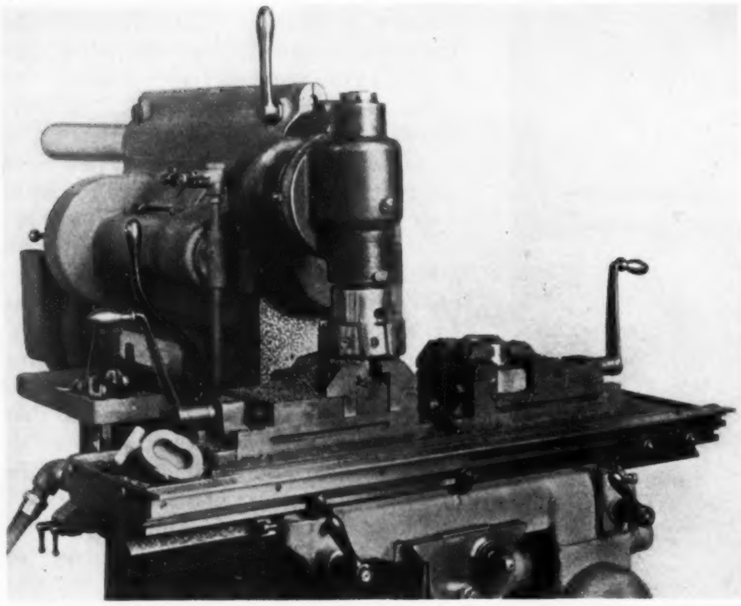

FIG. 9 RECIPROCATING MILLING WITH VERTICAL-SPINDLE MILLING ATTACHMENT

late Henry R. Towne, a Past-President of the A.S.M.E., and patented by him in 1893. It lends itself especially well to the milling of such articles as flatirons, an illustration of this being shown in Fig. 8. It would seem that such a method would be "the last word" in reducing time between cuts, but it has been found that ordinary work is of such a shape that this result does not follow. For instance, the caps and bodies of small pumps were at one time milled in this way at the rate of 60 to 70 per hour. When, however, this same job was put on the automatic milling machine, using the reciprocating method (Fig. 9), 90 per hour could be produced with the same rate of feed, since it was possible to mill the short way of the piece, and to eliminate waste which existed when using the rotary method. This seemed at the time a material gain, but to illustrate how far short it was of the possibilities, by taking advantage of modern methods as shown in Fig. 10, including the use of tungsten carbide cutters, and placing the job on a heavier type of milling machine, providing fixtures so that 8 pieces (4 caps and 4 bodies) are produced at each complete reciprocation, with the cutter running at a surface speed of 220 ft per min and a feed of nearly 24 in. per min, giving a chip per tooth of over 0.01 in., approximately 500 pieces per hour are produced.

While the cutting speed might be increased above 220 ft per min, this would not appreciably increase the production because of the time required for loading. On some other job, however, where the loading time would be less, the cutting speed might be increased correspondingly. All of these considerations have to be taken into account in deciding on the most effective method to use for a particular job. It is estimated that in commercial shopwork the production per hour per workman is now 50 per cent above what it was before the World War.

From the fact that there has been such a material increase of production in recent times, and because of such progress as has been indicated in this paper, there is reason to believe that the future still holds possibilities that are beyond our present conception, possibilities that give promise of greater attainments yet to come in both accuracy and speed.

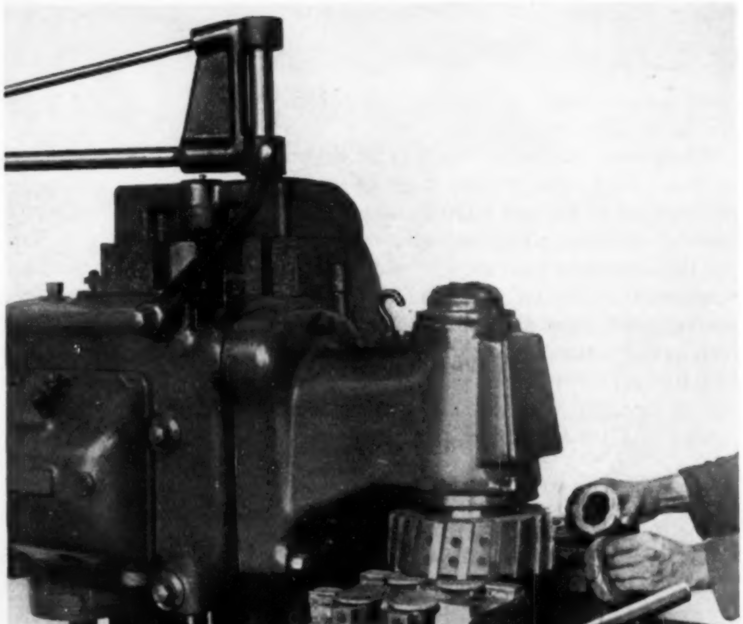

FIG. 10 MULTIPLE RECIPROCATING MILLING USING TUNGSTEN CARBIDE CUTTERS

The Newer

CUTTING-TOOL MATERIALS

Problems They Present in the Design of Machine Tools

BY A. L. DE LEEUW[1]

MACHINE tools differ from other machines in that they, by themselves, are not capable of performing useful work. Take a loom, put some thread in it, arranged in the proper manner, and the machine is capable of weaving a piece of goods. Take a lathe and put a piece of steel between the centers, and the machine is not able to do anything to this steel until we have provided it with a cutting tool, a thing quite extraneous to the machine itself.

The Germans recognize this fact by naming this class of machines *Werkzeugmaschinen*—tool machines. From this fact, that the machine cannot work without a tool, it follows that the design of the machine must be based, to a certain extent at least, on the characteristics of the tool. Obvious as this remark seems to be, it is a fact that it has not always been recognized. Much of the disappointment experienced by many people when they first applied high-speed steel was due to this lack of harmony between the tool and the machine, and this, in its turn, was due to a lack of understanding of the qualities of the then new cutting material. It was recognized that the new steel had some desirable qualities, but what these qualities were was not common knowledge, not even among those who should have known, and consequently they could not apply them properly in the shops or design the machines in which this material was to be employed. Some thought that its use consisted in the taking of very heavy chips, others that its value lay in its ability to cut metal at high speeds. Others claimed that it was useful only for roughing cuts, and not applicable when a good finish had to be produced. It was a common idea that the greatest possible production had been attained when the chips came off red hot—or at least blue.

As a consequence of this lack of knowledge, it took a number of years before the full benefits of the new material were realized. It was not recognized at first that new machines had to be designed to get the best results with the new tools. In a way it may be said that such designs were never made. Rather, the machine tools, as we know them now, are the result of a slow process of evolution.

We are again confronted with the same kind of problem which faced us when high-speed steel first appeared and which was not recognized at that time. Now it is tungsten carbide and similar materials which have appeared on the stage. We should not make the same mistake and waste years groping in semi-darkness. We should make ourselves acquainted with the properties of these new materials, and design or redesign or alter machine tools accordingly.

PROPERTIES AND LIMITATIONS OF THE NEW CUTTING MATERIALS

What are the properties of these materials? How do they help us, and in what manner do they limit us? When these questions have been answered to the fullest possible extent, then the problem before us is: How shall we construct machines which can make full use of their beneficial properties and which will be to the largest possible extent immune to frailties of the tool?

The outstanding qualities of tungsten and tantalum carbides are that they are extremely hard, and do not lose this hardness until they are brought to a very high temperature.

Their outstanding limitations lie in the fact that they are sintered materials, and therefore lack the strength of solid metals. In addition, tungsten carbide shows an affinity for steel which causes small pieces of that material to adhere to the tool, or—as it is commonly expressed—to weld to the tool.

Another limiting factor in the use of the carbide tools is the high price of the material. However, this limits their use only, and is no factor in the design or construction of the machine.

All other so-called qualities of the new tool materials are the natural results of the ones mentioned. They can be arrived at by reasoning and do not require experimentation to establish their existence, though such experiments would establish their extent.

To say, for instance, that these carbides permit the cutting of hard or gritty material is simply a more involved way of stating that they are very hard. To say that they are liable to crack or crumble under excessive pressure and that one must guard against vibration is merely another way of saying that they are not very strong. However, though the ordinary way of mentioning the qualities of the carbides may not be the most logical way, it is perhaps the best way, for it brings before the user as well as the designer the things he has to consider. For example, to say that the carbides can be brought to a very high temperature before they lose their hardness does not state quite so clearly

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what one can do with these cutting tools as to say that they can run at a high speed. For the benefit of the machine designer we can state the essential qualities of the carbide tools in this manner:

The smallest possible amount of tungsten or tantalum carbide should be used in the construction of the tool—this on account of the high price of the material. A proper balance should be struck between the first cost and the necessity of having enough material for repeated sharpenings.

Machines specially constructed for the use of the carbides should be capable of high speed. They should be massive, so as to absorb vibrations set up by the separation of the chip segments, and they should have no parts which, by their form or their material, are apt to vibrate in unison with the work. Careful design of the ribbing of the various elements of the machine will accomplish this object.

This taking care of vibrations is nothing new. It should be done whether carbide or steel tools are to be used. However, it is of more urgent importance with the new cutting materials. It is therefore necessary to go carefully over all the details of the machine that is to employ tungsten or tantalum carbide, and make sure that everything possible has been done to prevent the starting of vibrations—or their continuation, if conditions of tool and work have started them nevertheless. However, when all this has been done, there remains something to which no attention seems to have been paid in the past.

PERSISTENCE OF OLD PRACTICES IN TOOL HOLDING

To some extent the arrangement of the tools in such machines as lathes, planers, and shapers is based on old practice, when the operator had to guide the tool by hand. As an illustration, the workman who ran a lathe in the times before the slide rest was invented, used a long-handled tool. He held the cutting end with his right hand close to the work while the handle end was held tightly between his left arm and the body. It was the only possible way to hold the tool steady while taking a cut. We still have the same arrangement. Our lathe tools are still horizontal, while the pressure of the cut is in a nearly vertical direction. We are doing in the lathe what a carpenter would be doing if he used a chisel like the one shown in Fig. 1. Though such a chisel might have some advantages, in so far as there would be less chance of injury to the hand, the carpenter would not use the tool because it would be harder to guide, and especially because it would vibrate and produce rough work. It is just as easy to guide the tool in a modern lathe whether it is placed as it is now or in any other way, and therefore one of the reasons why the carpenter does not use a chisel like the one in Fig. 1 disappears, but the other remains.

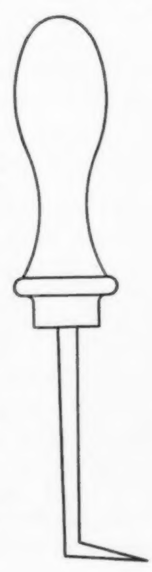


FIG. 1 THE KIND OF CHISEL A CARPENTER WOULD USE IF HE FOLLOWED LATHE-TOOL PRACTICE

If we forgot the historical reason why we hold a tool in the lathe the way we do, we should naturally place it in a manner like that shown in Fig. 2. Here the tool is held in such a way that the resultant of all the forces tends to compress but not bend it. This arrangement is merely illustrative. It shows the general relation between tool and work; it also shows that the tool should be so supported that the stresses will be directly transmitted to the frame of the machine.

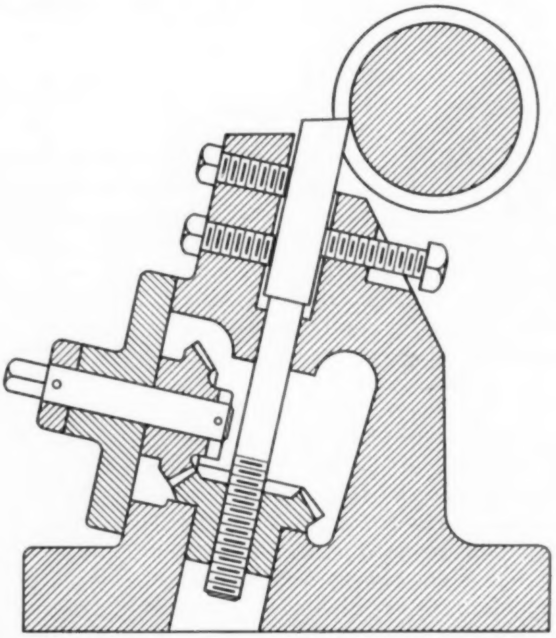


FIG. 2 THE LOGICAL ARRANGEMENT FOR A LATHE TOOL. THE RESULTANT OF ALL THE FORCES ON THE TOOL TENDS TO COMPRESS BUT NOT BEND IT

There are two ways in which the tool is bent in the present-day lathe. One is the direct result of the pressure of the cut, and the other of the pressure of the feed. Both pressures fluctuate between a minimum and a maximum. The minimum occurs at the moment a chip element has been split off, after which compression starts again and the pressure works up gradually to the maximum, which is reached immediately before the splitting begins. The curve is of the general nature of Fig. 3. The curve representing the fluctuations of the feed pressure is of the same general shape, but not neces-

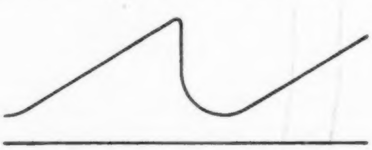


FIG. 3 HOW PRESSURE OF CUT FLUCTUATES IN A PRESENT-DAY LATHE

sarily of the same frequency. The two frequencies may help or hinder each other. The common form of round-nose tool is used to keep the two frequencies out of step.

VIBRATION PROBLEMS

The fluctuations of pressure cause corresponding variations in the amount of bending of the tool. Though everything possible may be done to hold the amount of overhang of the tool down to a minimum, there must necessarily be some overhang. If this overhang is considerable, there is a rhythmical bending and unbending of the tool, with corresponding rough work and danger of chatter. If the overhang is short, there is no perceptible bending—though of course there must be some—but there is a molecular vibration set up which may cause equally bad chatter. These bad results are undesirable when steel tools are used, but they are fatal in the case of carbide tools.

Tungsten carbide is more sensitive to the effects of vibration than steel, but not to such an extent as seems to be the popular belief. However, such effects are more undesirable than where steel tools are used, and for the following reasons: First, tungsten carbide costs several times as much as steel, and it is therefore more essential to guard against breakage or spoilage of any kind. In the second place, it requires much more time to resharpen a tungsten carbide tool than a steel one. This again means that a breakdown of a carbide tool causes a greater loss than one of a steel tool. However, the most important reasons why such great care should be taken to avoid vibrations are the facts that higher speeds can be used and that a much longer tool life between grindings is possible. It is the hardness which makes the long life possible, and the vibration which cuts the life short. Again, it is the ability to resist high temperatures which makes high speeds possible, and the vibration which breaks—or at least spoils—the tool.

It should be kept in mind that, if the carbide tools could withstand vibration equally as well as steel tools, it would still be more important to guard against vibration where they are used. That carbide tools suffer more is an additional reason, but not the main one.

There seems to be a popular belief, which has been expressed several times in magazine articles, that tungsten carbide tools in general require more power than steel tools for the same amount of cut. This is a fallacy. When a cut is taken with the same speed, the same feed, the same depth of cut, the same tool shape, and on the same material, it makes no difference as to the material of which the tool is made. There is no difference in the amount of power required if the conditions of the cut are the same. But, if one wishes to get the greatest possible benefits from the use of the carbide tools, one should not have the same set of conditions as when cutting with steel tools.

METAL REMOVAL WITH CARBIDE TOOLS

Tungsten carbide—and in the following the same arguments apply equally well to tantalum carbide—permits the use of much higher speeds, and when the same section of chip is produced, but at a higher speed, it is a matter of course that more power is required. This can best be expressed by saying that tungsten carbide *permits* the use of more power when cutting metal. There is another reason why, sometimes, more power is required, though the total amount of metal removed per minute is not increased. However, here again the conditions are not the same as they are when using a steel tool.

It is a well-established fact that the minimum amount of power is required for the removal of a given amount of metal when the section of the chip approaches most nearly a perfect square. As an example, less power is required when taking a cut one-eighth of an inch deep and with one-eighth of an inch feed than when the same amount of metal is removed with a depth of cut of one-quarter of an inch and with a feed of one-sixteenth of an inch. The difference is not very great in the example given, but becomes more and more the greater the ratio between the depth of cut and the feed. This applies equally well to steel as to tungsten carbide tools. One is limited as to speed when using a steel tool and must therefore use the greatest possible feed or depth of cut in order to obtain the greatest possible economy. The limit of speed with tungsten carbide is much higher, so that one has the choice of increasing either speed, depth of cut, or feed, and there are often conditions which make it advisable to find additional economy by increasing speed at the cost of feed or depth of cut.

This happens, for instance, when a heavy cut produces considerable spring in the work. Much lathe work is subsequently ground, and when the work is sprung, additional time and wheel wear are expended on account of this spring. In such cases it is advisable to reduce the feed. When the feed is cut in two, but the speed doubled, there is no gain of time in the lathe operation itself, but a later gain is made when grinding. In such a case there is a small loss of power, but it should be kept in mind that this is the result of a change of conditions of the cut and not of the fact that tungsten carbide is used. The same loss would have occurred if a steel tool had been used.

A similar condition is found in milling practice when frail work must be machined which cannot stand a heavy cut or which cannot be solidly clamped in the fixture on account of spring or distortion. In the latter case a lighter feed and greater speed subject the work to less pressure and make it possible to hold it against the cut though it is clamped but lightly. In the former case the lighter feed may result in acceptable work being obtained with one cut, whereas two cuts would be required with the heavier feed.

We find, then, that the design of a lathe arranged for the use of tungsten carbide tools must include a changed construction of the tool holder and, probably, as a consequence, of the carriage, the bed, and possibly other elements, and that it must include provision for much higher speeds.

BEARINGS FOR LATHES USING CARBIDE TOOLS

This increase of speed involves quite a number of elements. The spindle must run at a high speed, and at first glance this would seem to indicate the necessity of using ball or roller bearings. A further analysis, however, shows that such bearings are not an unmixed blessing. Both ball and roller bearings are in themselves sources of vibration. The effect can be minimized by careful construction and design, but it should be kept in mind that the natural result of the use of such bearings is vibration.

Figs. 4(*a*) and 4(*b*) illustrate why such vibrations may be expected. In Fig. 4(*a*) the spindle rests on a single ball, while in Fig. 4(*b*) it rests between two balls. This change of conditions is caused by the revolution

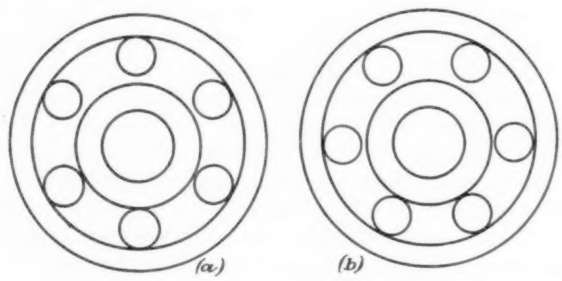


FIG. 4 WHY VIBRATIONS MAY BE EXPECTED IN LATHE SPINDLES RUNNING AT HIGH SPEEDS

(*a*) Spindle resting on a single ball
(*b*) Spindle resting on two balls

of the spindle and occurs at regular intervals. There would be no change in the position of the center of the spindle if there were no clearance between the ball races and the balls. It is true that this clearance is very small; nevertheless it is there and it causes the inner ball race and the spindle to move up and down half as many times per revolution as there are balls in the bearing. It may well be that the spindle and its parts are so heavy that they cannot move bodily at the rate of speed mentioned, but in that case they will be submitted to a corresponding number of blows, and the vibrations are not movements of the entire body of the spindle, but molecular vibrations, which may be just as bad if not worse.

There are ways to overcome this difficulty, some of which work well at relatively low speeds, but not so well at high speeds. One of them is the well-known method of preloading the ball or roller bearing. This is really a way of eliminating the small amount of clearance between races and balls. In fact, the balls and races are compressed, and, to a small extent, the balls are made to dig into the races. This would seem to be a perfect solution of the problem, but experience with grinding machines has shown that the remedy is a partial one only.

After all, the changes which take place when the inner ball race now rests on one ball and now on two, are equivalent to so many blows. The vibrations are less in amplitude, but they are not absent. Another way would be to use two ball bearings close together and with different numbers of balls. This would not eliminate the vibrations of the spindle, but, on account of their high number, would make molecular vibrations out of what otherwise would be bodily movements of the spindle.

It would seem that the safest way would be to come back to the old-fashioned, but safe, solid bearing, depending on the proper maintenance of the oil film for the high speed. Care should also be taken to confine the spindle endwise by as short an arrangement as possible. Expansion and contraction of the spindle are unavoidable, and the amount is greater when running at high speed, so that, with carbide tools, there is a greater chance of the spindle's sticking than in the lathe using steel tools.

THE QUESTION OF DRIVE

As to the drive itself, this cannot be disposed of in a single sentence. A sharp distinction must be made here between general-utility and special machines. A general-utility machine must take care of the entire range of diameters of work between the maximum swing of the lathe and the smallest diameter which can be effectively produced on the machine. It must have the necessary speeds for tool steel and brass. As a matter of fact, no commercial machine is built for this entire range. A lathe of 42 in. swing does not have all the speeds required for a 42-in. piece of tool steel and a $^{1}/_{2}$-in. piece of brass, but, as a rule, an attempt is made to give the machine as wide a range as is reasonably possible.

Conditions become worse when the same machine is to use steel and tungsten carbide tools, and a choice must be made as to whether the higher or the lower range of speeds should be sacrificed. Such a choice does not need to be made when the lathe is designed for the use of carbide tools exclusively, or even mainly. The high range of speeds would be selected. The question would remain as to the range and number of these speeds. Any wide range of speed, and especially if the speeds have a moderate ratio, requires gears or belts for the speed-changing mechanism, unless one should use some friction device. The last-named arrangement is not reliable, and even belts are no longer tolerated, so that there remains only some gear-shifting device in addition to the speed variations obtainable in the motor itself.

With any gear-shifting device there must finally be a gear on the spindle. If the spindle is to run at a high speed, this speed may well be too high for silent running. Other gears in the mechanism will probably run at still higher speeds and be even more undesirable. This shows that there is a serious problem to be solved in the design of a general-utility lathe, even if the machine is limited to the use of carbide tools only. The simplest problem presents itself when the lathe is to be used over a limited range of sizes and materials only. Such a machine is not a special machine but a limited-purpose machine. It is in such machines that the greatest possible benefits of the new cutting materials can be

realized, and where the problems to be solved are the simplest.

Gear trains and gear-shifting devices cannot be entirely avoided, except in special constructions. To assure the quietest possible running, helical or herringbone gears should be used. In neither case is it possible to shift the gears, and some clutch device must be used. A slight axial displacement of a shaft is not harmful when using helical gears, but some provision should be made against such possible displacement when using herringbone gears.

The best arrangement would be had if it were possible to connect the motor directly with the spindle, or to make the spindle the armature shaft of the motor. The different speeds would then have to be provided by the motor itself. This is entirely practical when direct current is available. However, direct current is no longer in favor in the machine shop, and it is therefore necessary to use a motor-generator in addition to the motor itself, and this is an objectionable complication, except where a number of such machines can be served by a single motor-generator.

Alternating-current motors can also be arranged for a number of speeds, but whereas it is possible to have as many steps as one wishes between maximum and minimum speeds when using a direct-current motor, alternating current permits only as many speeds as the possible arrangements of the poles in the motor allow. Besides, with a range of four to one, a range easily obtainable with direct current, the motor becomes unwieldily large. However, such motors have been made, and it is possible to get a number of additional speeds by the use of a frequency changer.

An objection to the direct-current motor is that the speed at either end of the range may not be the desired one. This, of course, is also true of the alternating-current motor, but there again the frequency changer comes to our assistance.

As to the carriage, this should not span the bed, as is the present practice. All of the carriage should be in front of the center of the lathe. This gives the greatest possible freedom for the chips, and, what is of more importance, it eliminates bending of the carriage, as the tool is always directly over the metal of the bed.

THE TAILSTOCK SPINDLE

The most serious problem is probably met in the construction of the tailstock spindle. The speed of the work may be so high that the ordinary construction of the dead center is no longer practical. Even at the present day, some lathes are constructed with a ball or roller bearing for the tail center. However, this method has the same objectionable features that were met in the live spindle. The final solution will probably be a live tail spindle. It would not be necessary to run it at the same speed as the work spindle—about half that speed would be sufficient. Such a construction would require a connection between the two spindles.

The form of the bed is largely determined by the foregoing points. It should be kept in mind that headstock and bed should be in one casting to obtain the best results as to rigidity.

Lubrication also offers some problems of its own. Not only is the designer dealing with high speeds, which is a problem common to many other kinds of machinery, but there is danger of the lubricant's catching fire on account of the high temperature of the chips. The spindle and live-tail-spindle bearings should both be well protected so that no lubricant can escape toward the work, or, if this cannot be conveniently done, a non-inflammable emulsion of oil should be used as lubricant.

Many of the foregoing remarks apply equally well to other types of machine tools, but they cannot be used blindly, not even in the design of lathes. Supposing, for instance, that tantalum carbide could be used successfully for the cutting of steel—something which has not yet been proved beyond the shadow of a doubt—a heavy forge lathe would have to be dealt with in an entirely different manner from that for a small production lathe.

BORING-MACHINE PROBLEMS

A boring machine for large cylinders does not present the same problems as a small lathe, but the fundamental points to be considered are the same: avoidance of vibration, solid tool support, and sufficient speed. The proper speed is easily obtained in this case, and the problems of lubrication are about the same as one would meet in the construction of a similar machine using steel tools, but it is more important that the boring bar should have the greatest possible diameter.

Vertical boring mills present some very difficult problems. This is due to the fact that such a machine is really two machines in one, and the requirements of the one are not the same as those of the other. If the machine were exclusively used for boring, the cross-rail would have to be of the fish-belly type, with a large bar in the center to which the boring bar proper could be attached. This boring bar would be piloted in the spindle. If, on the other hand, the machine were used exclusively for turning and facing, the housings should be of the rectangular type—that is, the front and rear of the housings should be vertical and the cross-rail should be clamped across these housings. The front of the rail should be far enough back to allow for a very deep tool slide so as to have sufficient support under the tool. In the nature of the thing, the design of a vertical boring mill must always be a compromise.

There is not much that can be done to adapt the present type of drill press better to the requirements of the new tools. Tungsten carbide can only be used as tips for the drilling tool, and this limits its use to the larger sizes. There is, consequently, no problem of high speeds. Neither is there a problem of reducing overhang, for this is the natural result of the shape of the tool. However, there is a possibility of increasing the life of the drill, be it a steel one or one of tungsten carbide. As with the lathe, the present form of the drill press is a relic of the past. However, its shape still has its uses: it permits the drilling of large as well as

small pieces, and of high as well as low ones; and for jobbing work such an arrangement meets the requirements.

But at the present time the greater part of the drilling done is on mass-production work, and a machine may be employed for days or weeks or even years on one piece, or on pieces of one size. Here the wide range of the upright drill press is of no advantage and merely weakens the machine, besides adding to the first cost.

Experiments have shown that a central support of the drill doubles, or almost doubles, its life between grindings. This means that all overhang must be eliminated and that the drill should be in the center of the frame. Such a construction leads to many other simplifications but reduces its range. In other words, there is one type of design which is right for the jobbing shop and another one which is better for mass production.

PLANERS AND SHAPERS

Of an entirely different type are the problems connected with arranging reciprocating machines, such as planers and shapers, for the use of tungsten carbide tools. In the first place, it is difficult to give as much speed to a planer table as it might require for some kinds of work. In the second place, as the tool does not stay in the work, it is subjected to shock when entering. In the third place, it is more difficult to provide for a good tool support than in the lathe.

The only planer drive so far developed which permits of reasonably high speed is the direct motor drive. The limitations of belts and the momentum of the driving pulleys when running at high speed hold possible table speeds down to 125 or, at the most, 150 ft per min. There is no theoretical limit of speed when the planer is driven by a reversible motor. However, in practice one strikes a limit as soon as one tries to run at speeds higher than can be obtained with a well-designed belt drive. This limitation is the result of the facts that it takes some time before the motor is up to speed, and that, at high speed, the table has run a considerable distance before the highest possible speed has been attained. This makes the planer unfit for short strokes, unless one is satisfied with the reduced speed. Even on long strokes there is such a large proportion of the stroke used for acceleration and deceleration that but a small part is run at the maximum speed.

This defect is reduced by the use of a motor with high starting torque, and still further by the use of a much larger motor than would be required for the movement of the table and for the cut; in other words, by using a motor large enough so that a large percentage of its power can be used for acceleration only. Though this way out of the difficulty seems to be simple enough, it is not quite so simple as it may appear at first glance. Increasing the power of a motor means either a larger frame and rotor or a higher speed of the rotor. In the first case, the momentum of the rotor is increased in proportion to its weight, and in the second case, in proportion to the square of its speed—or almost so. As the momentum of the rotor is a large proportion of the total momentum, it is easily seen that a large part of the increase of power of the motor is used to overcome bad conditions caused by this increase. However, when all this is said, it remains true that the extra power of the motor enables one to obtain higher speed, with less waste of time for acceleration.

SHOCK AND ITS AVOIDANCE

There remain the problems of shock and proper tool support. As to the first, what was objectionable in the slowness of the planer to come up to full speed is helpful as to shock, for the tool would strike the work long before the table had reached its ultimate speed. If, however, means have been provided to accelerate the table quickly, then the tool strikes the work at high speed and there is sufficient shock to cause harm to the tool.

These conditions are not new. When at first high-speed steel was used for planer tools, it was found—or it was thought that it was found—that the metal could not stand the shock of entering the cut at what was at that time high speed. It was proposed to drive planers with compound-wound motors, but in this case the table would attain a relatively high speed before the tool had entered the work, and a later proposal was to provide this motor with a flywheel—to curb its ambition, so to say. The motor was to be so constructed as to permit it to run slower under load than when idle, in order to take care of the reversal, and then a flywheel was added to prevent it from running slower under load.

The problem of avoiding shock as much as possible is, to a certain extent, solved by providing a better tool support. It is therefore essential to construct a support which eliminates any bending of the tool due to the pressure of the cut. A tool apron can be constructed, which holds the tool in the same manner as was recommended for the lathe, though it is not possible to transmit the pressure directly to the bed of the machine. This much can be done, however: the tool support can be arranged so that the pressure is approximately in the direction of the axis of the tool.

From a purely mechanical standpoint, a hydraulic drive would solve the problem of high speed combined with rapid acceleration and deceleration as well as absence of shock. To what extent it is a practical solution depends on the economical aspects of the case. As an illustration of just what such a hydraulic drive would mean, the following example is taken. It is supposed that the table must move in either direction with a speed of 200 ft per min and that a pressure of 25,000 lb is required for table movement and cut. It is further supposed that a hydraulic pressure of 500 lb per sq in. is available.

From the foregoing figures it follows that the driving cylinder must have an internal area of 50 sq in., and therefore a diameter of 8 in. The volume of oil passing through the cylinder is 120,000 cu in. or 520 gal per min. There are various arrangements of piping and

(*Continued on page 353*)

The National HYDRAULIC LABORATORY[1]

II—Details of the Supply and Measuring Basins, Main Flume, Discharge Tanks, Etc.

By HERBERT N. EATON[2]

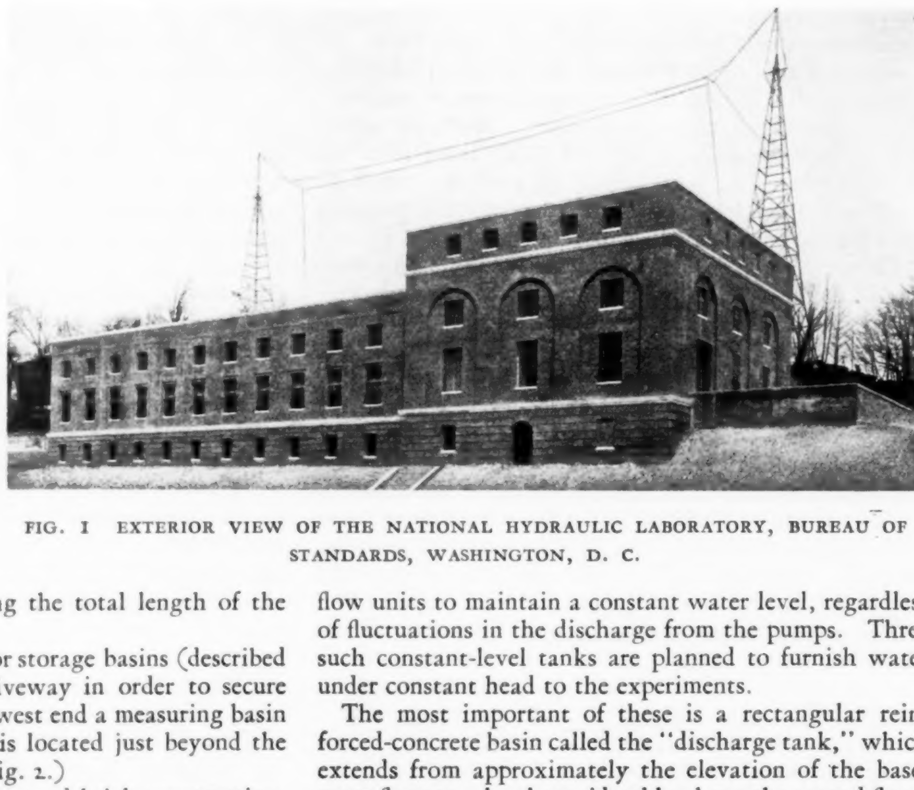


FIG. 1 EXTERIOR VIEW OF THE NATIONAL HYDRAULIC LABORATORY, BUREAU OF STANDARDS, WASHINGTON, D. C.

THE laboratory comprises a building with a rectangular head at one end which is 82 ft long by 92 ft wide (Figs. 1 and 2) and which is four stories high, including the basement. From this head a wing 60 ft wide extends westward 203 ft, thus making the building 285 ft long. There are three stories in the wing, including the basement. If it should ever be necessary to extend the laboratory at some future time, a head similar to that at the east end may be added at the west end, thus making the south and north elevations symmetrical and making the total length of the building 367 ft.

At the east end, the supply or storage basins (described later) extend beneath the driveway in order to secure more surface area, and at the west end a measuring basin for volumetric measurements is located just beyond the wall of the building. (See Fig. 2.)

The building is of steel-frame and brick construction, the exterior face brick matching the other buildings at the Bureau of Standards. The architecture is simple but appropriate.

The water supply for experimental purposes will be stored in two large supply basins which occupy about two-thirds of the ground area of the building. (See Fig. 1.) For reasons which will appear later, the normal water level in one of these basins will be considerably higher than in the other, and consequently this basin is termed the "high-level supply basin" to distinguish it from the other or "low-level supply basin."

The water will be pumped from the supply basins into constant-level tanks which will be equipped with overflow units to maintain a constant water level, regardless of fluctuations in the discharge from the pumps. Three such constant-level tanks are planned to furnish water under constant head to the experiments.

The most important of these is a rectangular reinforced-concrete basin called the "discharge tank," which extends from approximately the elevation of the basement floor to a level considerably above the second floor. This discharge tank is intended to supply large quantities of water to the main flume and to other equipment on the first floor. Six pumps having a combined capacity of about 285 cfs will supply this discharge tank.

A steel constant-level tank containing three independent compartments, each supplied by a separate pump, will be mounted near the ceiling of the second floor to supply water to experiments on that floor. The pumps supplying this tank will have a total capacity of about 35 cfs. Another steel constant-level tank with two compartments will be mounted on the third floor to supply experiments on this floor requiring up to 10 cfs of water. The tanks on the second and third floors will be able to serve any of the floors below them.

The main flume already referred to (Fig. 2) is the principal piece of hydraulic equipment in the building for large flows of water, and will permit experimental

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Part 1 appeared in the April issue.

[2] Hydraulic Engineer, U. S. Bureau of Standards, Washington, D. C. Mem. A.S.M.E.

work with flows up to about 300 cfs, which will be approximately the maximum ultimate capacity of the laboratory. It is 12 ft wide, has reinforced-concrete walls 12 ft high, and is about 217 ft long. At the discharge end the water will either be diverted into the measuring basin or will fall into a tumble bay, whence it will flow back to the supply basin through one of the return channels, through the wing of the low-level supply basin, or through one of the two venturi-meter lines.

THE SUPPLY BASINS

There were several reasons for providing two supply basins instead of a single one of equivalent size. With the first-floor elevation given as 290 ft, it was found that in order to allow properly for the circulation and measurement of a flow of 300 cfs in the main flume, the level in the supply basin would have to be kept down to about 279 ft. However, it is unnecessary to maintain this low level for the great majority of tests, for which the smaller pumps will be used. For these tests the supply-basin water level can be as near the first-floor level as is feasible, thus reducing greatly the pumping head for the pumps which will be used most.

To meet these considerations, two supply basins were provided, the first, called the "low-level supply basin" having its normal water level at elevation 279 ft and serving as a supply for the large pump units, Nos. 1, 2, and 3. The second, known as the "high-level supply basin," is to have its normal water level at 288 ft and will serve as a supply for the smaller pump units, Nos. 4, 5, and 6. (See Fig. 2.)

This arrangement will also permit the maintenance of nearly constant water level in the low-level supply basin when large flows of water are diverted into the measuring basin for volumetric measurement, and consequently the pumping head can be maintained nearly constant. This will be accomplished by allowing water to flow from the high-level supply basin into the low-level basin while the measuring basin is filling. A 5-ft-square quick-opening sluice gate and two 20-in. quick-opening valves connecting the two basins will be provided for this purpose.

A further important feature of the low-level supply basin is that it provides ample storage space for any quantity of water which might be released accidentally from the discharge tank or the main flume, and thus eliminates any danger of flooding the first floor.

Another important advantage of having two supply basins is the fact that, should it be necessary to empty one basin for cleaning or repairs, the laboratory can still continue to operate at perhaps half-capacity with the other supply basin, instead of shutting down, possibly for weeks.

The high-level basin will also act as a settling basin for experiments involving the movement of sand or silt. The surface water can flow over the overflow crests near the east end of the dividing wall between the two basins into the low-level basin, while the fine silt and sand will settle out and can be removed when the high-level basin is emptied.

THE MAIN FLUME AND DISCHARGE TANK

There was considerable difference of opinion as to the size of the main flume. The sizes of cross-section advocated ranged from 10 ft wide by 10 ft high to 15 ft wide by 16 ft high. A cross-section 10 ft by 10 ft would permit weir tests with a maximum flow of about 250 cfs, while a cross-section 15 ft by 16 ft would permit such tests with a maximum flow of about 500 cfs. Since the design of the entire laboratory depended on the size of this flume, the decision as to this point was of fundamental importance.

In arriving at a decision, it was necessary to consider many factors—for example, the effect of the size of the flume on the cost of the building, the power required to circulate the water, etc.

The power required to circulate the water proved to be a very important factor. For the 10-ft by 10-ft cross-section the maximum power required for any test which could be conducted would be about 1300 hp, while for the 15-ft by 16-ft cross-section the corresponding power would be about 3400 hp (in part owing to a proposed 40-ft-high discharge tank.) It is feasible to furnish 1300 hp electrically to the laboratory occasionally by special arrangement, but any power appreciably in excess of this would probably have to be furnished by Diesel engines, gasoline motors, or some similar means. This was considered to be undesirable.

It should be borne in mind that it is not proposed to operate the large flume at full capacity except very rarely—when it is desired to investigate some question of scale effect, for example. For the great majority of work which will be done in this laboratory, tests utilizing far smaller flows will be adequate. The question was then that of deciding how far it was worth while to go in the direction of providing for extremely large flows of water, which may be required very rarely, which require an extremely large amount of power, which require special and expensive equipment, and which require a sacrifice of floor space and facilities for the smaller-scale tests, the latter constituting perhaps 90 per cent of the work of the laboratory.

After all of these factors had been considered, it was decided to compromise on a flume 12 ft wide, with walls 12 ft high, and with a length of about 217 ft, the construction being of reinforced concrete.

The two fundamental questions involved in the design of the discharge tank which supplies the main flume with water were as to its form and whether it should be of steel or reinforced concrete. The design recommended for the proposed 15-ft by 16-ft flume comprised a circular steel tank 40 ft in diameter discharging the waste water through a vertical pipe 5 ft in diameter. A circular steel tank would undoubtedly have been the best and cheapest form of construction had it not been necessary to provide for the large gate and pump discharge openings and for an adjustable overflow unit or units. The overflow units must be symmetrical and carefully balanced in order to avoid large stresses and difficulties in handling. In a circular tank, only a single circular unit extending over the whole area of the tank is feasible. Such a unit

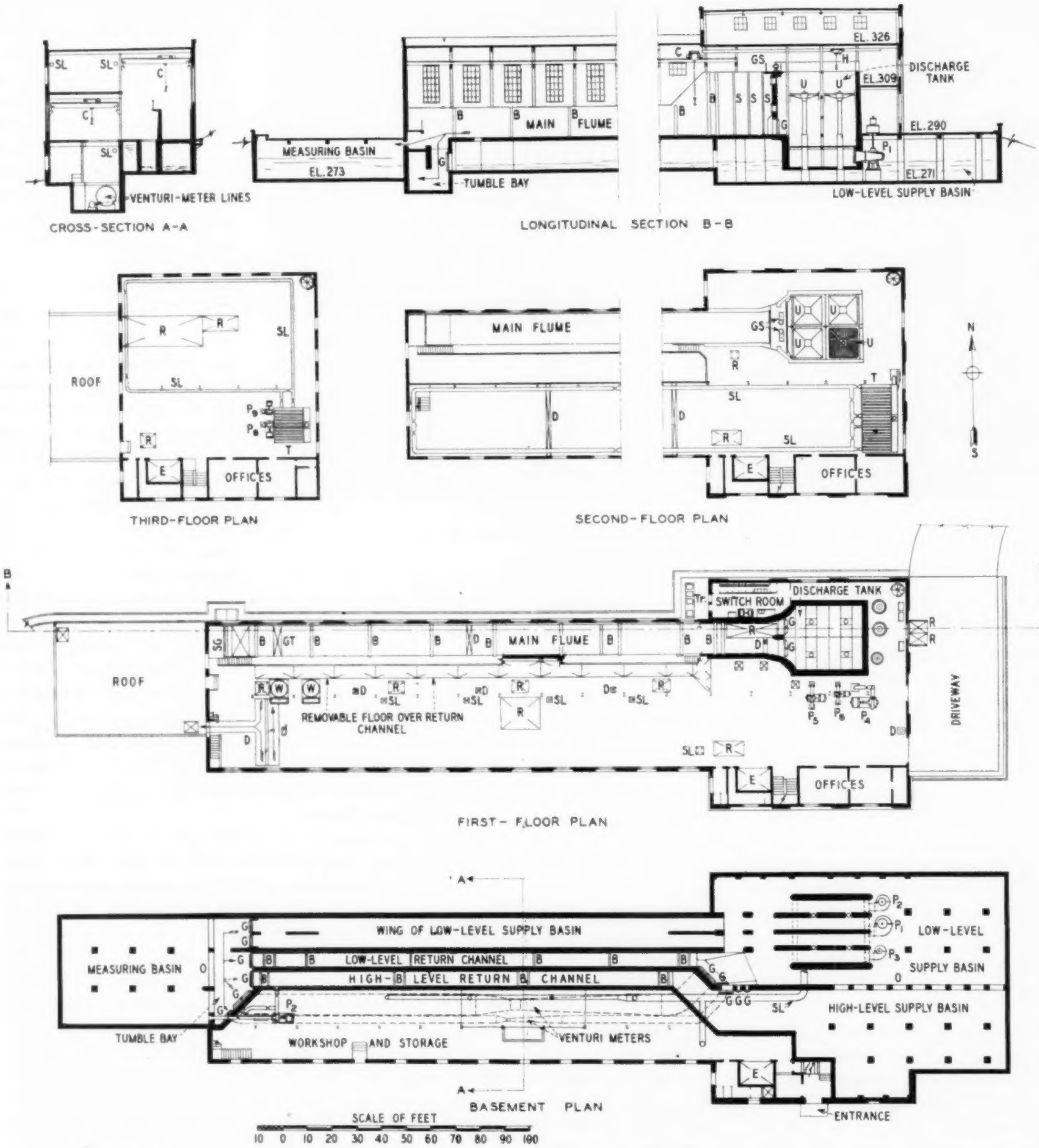


FIG. 2 FLOOR PLANS AND SECTIONAL ELEVATIONS OF THE NATIONAL HYDRAULIC LABORATORY, WASHINGTON, D. C.

B Bulkhead Slot	E Elevator	R Removable Flooring	G Gate	SG Swinging Gate	U Overflow Unit
C Crane	H Hoist	S Screen Slots	GS Gate Stand	SL Supply Line	W Weighing Tank
D Drain	P Pump	Tr Transformers	GT Gravel Trap	T Constant-Level Tank	O Overflow Crest

(weighing in the neighborhood of 30 tons for a tank 40 ft in diameter) would be difficult to handle and would require heavy overhead construction to carry the hoist.

With a rectangular tank, four square units can be used, weighing not over 5 tons each. Furthermore, the tank can be strengthened by running cross-ties from wall to wall between the overflow units. The large upkeep item of painting is also practically eliminated by building the tank of concrete. Consequently, the decision was in favor of a rectangular reinforced-concrete tank.

As constructed, the discharge tank has a cross-section 27 ft wide by 26 ft long, inside dimensions. The floor is at elevation 277 ft, and the walls extend continuously to elevation 315 ft and are carried over part of the perim-

FIG. 3 GENERAL VIEW OF WING OF LABORATORY FROM CONTROL PLATFORM AT HEAD OF MAIN FLUME

eter of the tank to elevation 319 ft so that the head can be increased by 4 ft, if desired, by inserting a few steel plates. A maximum head of 29 ft can thus be obtained at the floor of the main flume.

Two 6-ft-square electrically operated sluice gates are mounted side by side, with the bottoms of the gate frames flush with the floor of the flume. The flume walls are flared out at their junction with the discharge tank, and the gates are so placed in this transition section as to afford the desired 12-ft-wide clear opening. A stream-lined pier is built between the gate frames.

The main source of supply for the discharge tank will be the three vertical-type submerged suction pumps, Nos. 1, 2, and 3, arranged along the east face of the tank (see Fig. 2). It is planned that these shall comprise ultimately one 30-in., one 36-in., and one 42-in. pump, the discharge outlets connecting with expanders through the wall of the discharge tank and ending in flap valves. The water will pass upward through one or two layers of stilling plates mounted at elevation 285 ft.

Four overflow units having a total crest length of about 2000 ft will be mounted in the discharge tank. Each will consist of a central vertical waste pipe 22 in. in diameter, at the top of which four radial collecting troughs extend to the corners of the unit to take the discharge from a series of lateral troughs. The object is to provide as great a length of overflow as possible with the overflow edges in a horizontal plane, so that the change in water level due to a change in pump discharge may be reduced to a minimum.

Although the design of these overflow units has not yet been completed, it appears that each unit will weigh a little under 4 tons, including the vertical waste pipe. It is anticipated that they can be so designed that, as the water level rises toward the crests of troughs, the units will have a slight buoyancy and can be floated to the desired position. However, a hoist overhead will be used to aid in controlling the motion as a matter of safety. Provisions will be made for pinning the arms of the overflow units in position, once the unit has been brought to the desired level.

Each overflow unit can be set with its crests at any desired elevation between 292 ft and 315 ft, thus giving a wide range of heads for the main flume. Each vertical waste pipe will pass down through a 24-in. pipe casing equipped with a stuffing box, and will discharge into one of the passages beneath the discharge tank.

Just below the head gates the walls of the main flume extend to elevation 315 ft for a distance of 27 ft downstream. This high-walled section is equipped with stop log grooves and with grooves for baffles. Lateral steel ties have been provided in this section to take in part the enormous thrust of the water on the walls when the forebay is full. There is also provided here a section of removable floor in the flume for the purpose of passing the discharge end of a siphon spillway through the floor into the channel below.

There are a number of 20-in.-square openings framed with cast iron in the south wall of the main flume. Steel or glass cover plates can be mounted in the castings. It is doubtful whether it will be possible to see through 12 ft of water flowing in the flume, but it is expected, nevertheless, that the windows will be useful. Two doors 2 ft wide by 4 ft high are also provided in this wall. These are also framed with wall castings to which cover plates can be attached.

Seven bulkhead slots framed with steel have been set in the walls and floors of the main flume. In addition there will be provided drains in the floor, piezometer connections in both floor and walls, and a gravel trap at the lower end.

THE TUMBLE BAY

At the discharge end of the main flume, the water will fall into a tumble bay from which the three return channels and the two venturi lines lead back to the supply basins. The water first strikes the floor at elevation 269 ft, where it is turned into a horizontal direction. It is then turned through 90 deg horizontally into the main portion of the tumble bay, where it passes through baffles.

A model of the tumble bay, the lower ends of the main flume, the return channels, and the venturi lines was

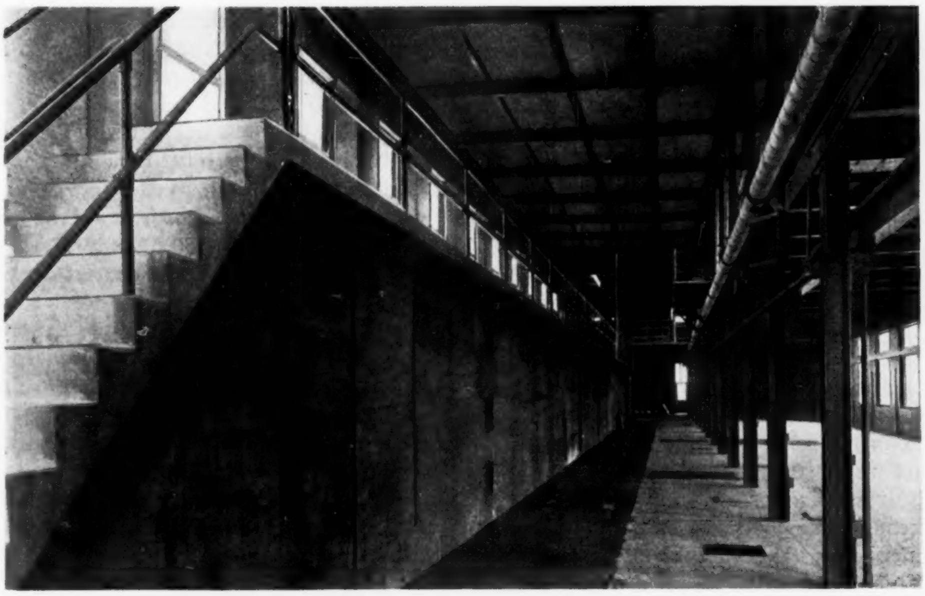


FIG. 4 VIEW OF FIRST FLOOR OF LABORATORY FROM WEST END OF BUILDING
(The steel-plate flooring next the flume wall covers the low-level return channel.)

constructed to a scale of 1:32 and was tested to determine the nature of the flow to the return channels and the venturi lines when large flows were involved, and also to determine qualitatively what provision could be used to prevent air bubbles from reaching the venturi lines.

It was not possible to design the tumble bay entirely upon the basis of optimum hydraulic characteristics, since there was scarcely room to provide and to gate the outlets to the return channels and the venturi lines. In fact, it was necessary to turn part of the east wall of the chamber at an angle of 45 deg with the axis of the building to obtain the necessary room for the gate frames for the venturi lines.

THE RETURN CHANNELS

The low-level return channel is 6 ft wide by 13 ft deep, its floor lying at elevation 277 ft. This low floor level was required in part to prevent backing up the water too much in the tumble bay for large flows, and partly so that it would add to the surface area of the water in the low-level supply basin. Bulkhead slots are placed at intervals to facilitate the mounting of models. This channel can be used as an experimental flume.

A channel of the same width and depth as the low-level channel connects the tumble bay with the high-level supply basin. This channel will act as a collecting channel running nearly the entire length of the laboratory to return to the supply-basin water from all experiments supplied by the smaller pumps, Nos. 4, 5, and 6, which take their supply from the high-level basin. It is provided with four pairs of bulkhead slots so that it can be divided at will into one or more independent basins, each of approximately 3300 cu ft capacity, for use in measuring, supplying, or storing water. If the basins are used for volumetric measurements, the double slots will permit leakage through the bulkhead walls to be measured.

The wing of the low-level supply basin will increase the surface area of the low-level supply basin and can be used as a return channel if desired. Wall castings have been placed at each end of this channel so that cover plates can be mounted and the channel thus closed off at will.

THE VENTURI-METER LINES

Two return lines constructed of steel pipe and containing venturi meters will connect the tumble bay with the low-level supply basin. One of these lines will be 8 ft in diameter, while the other line will be 3 ft in diameter. These two meters will be capable of measuring any flow within the capacity of the laboratory, from the maximum down to perhaps 10 cfs. Special attention has been given to the design of these lines, since the venturi meters will be used, not merely to measure water, but also for experimental work—for example, the study of the boundary layer in flowing water, the resistance of streamlined bodies, velocity distribution over the cross-section of a pipe, scale effect, etc.

THE MEASURING BASIN

The measuring basin adjoins the tumble bay and lies outside the west end of the building. It is 60 ft long, 42 ft wide, and 14 ft deep from the floor to the overflow crests. The cubical content is therefore 35,280 cu ft, which will provide a filling time of 142 sec for a flow of 250 cfs, or of 180 sec for a flow of 196 cfs, which is probably about the shortest time which would be used for precise measurement. The measuring basin is smaller than is desirable for the measurement of the maximum flow, but should suffice for the first five years or so, since the laboratory will not have its entire projected pumping capacity at first.

In order to divert the flow from main flume into the measuring basin, some form of swinging gate will be required. This gate has not yet been designed, but several proposed designs have been given consideration. The building has been so planned that any one of several types of gates can be mounted readily at the end of the flume. This gate will require careful study, and it is planned to experiment on various-sized models before attempting to prepare the final design.

WATER DISTRIBUTION AND DRAINAGE

The portion of the first floor outside the main flume

will be supplied with water through a 30-in. supply line from the discharge tank. Any combination of pumps Nos. 1 to 6 can be used for this purpose. The overflow units in the discharge tank will thus serve to provide a constant head for such tests, and no auxiliary constant-level tanks will be needed for individual experiments unless interference between different experiments drawing relatively large quantities of water should occur. The water from experiments on the first floor will be returned either through the high-level or the low-level return channel, depending on which pumps are being used. At the west end of the building there are also provided two lateral channels just below the first-floor level, one wasting into the high-level return channel, the other discharging into the measuring basin, so as to provide a convenient means of measuring large quantities of water from experiments on the first floor.

It is planned to loop a 16-in. supply line entirely around the balcony, starting from the three-compartment constant-level tank at the west wall of the building. This tank will be supplied from pumps Nos. 4, 5, and 6, mounted on the first floor near the walls of the discharge tank. These pumps will have capacities of 20, 10, and 5 cfs, respectively, and will be connected individually into the compartments of the constant-level tank, as well as into the discharge tank, as already described. Three lateral troughs have been built into the floor at intervals along the balony for draining models on this floor. These will discharge the water from the tests through down-spouts into the high-level return channel.

A two-compartment constant-level tank supplied by two 5-cfs pumps (Nos. 8 and 9) mounted on the third floor is planned. These two pumps may take their suction from one compartment of the constant-level tank on the second floor or from the discharge tank in order to reduce the pumping head.

For draining experiments on the third floor, there will be provided a 14-in. pipe line just below the floor, with frequent vertical connections extending up through the floor.

A 16-in. pump (No. 7) will be mounted on the basement floor near the wall of the tumble bay for the purpose of emptying the measuring basin into the high-level return channel, filling the measuring basin, and pumping from the low-level basin to the high level.

The maximum quantities of water which can be supplied to the various floors and the corresponding heads are as follows:

Floor..........	1st	1st	1st	2nd	2nd	3rd
Quantity in cfs.	300	35	10	35	10	10
Head in ft......	29	33.25	47.5	14.25	28.5	11.5

In addition, by using a sump pump, quantities up to 10 cfs can be supplied to the basement under a head of about 65 ft.

THE CRANES

A 5-ton crane under the balcony will serve to pick up loads directly from trucks at the east end of the building and will operate nearly to the west wall. It will also be able to lower loads through the first floor to the basement and to the venturi-meter pit.

Another 5-ton crane will span the space from the central columns of the building to the north-wall columns in the central portion of the building. It will be able to lift loads from the first floor and deposit them on the projecting sections of the balcony or at any point within the walls of the main flume or the return channels.

A 5-ton hoist will also be mounted on a tram rail passing over the centers of the four overflow units in the discharge tank in order to facilitate the handling of those units. The tram rail will also be carried over the high-wall section of the main flume.

Space for a future freight elevator has been provided in such a position that it will serve the basement and the three floors in the head of the building. This elevator will be useful for transporting from one floor to another sand, gravel, models, and many other articles and materials which cannot be handled conveniently by the cranes.

GENERAL INFORMATION

The following table gives in convenient form data as to the various features of the building:

Contents of building, including all basins..............	1,336,100 cu ft
Measuring basin, surface area..........................	2,520 sq ft
Measuring basin, depth.................................	14 ft
Measuring basin, capacity..............................	35,280 cu ft
Supply basin, high-level:	
Surface area...	4,670 sq ft
Capacity (normal water level)..........................	66,000 cu ft
Supply basin, low-level:	
Surface area...	7,880 sq ft
Capacity (normal water level)..........................	45,000 cu ft
Floor area available for equipment and tests...........	34,000 sq ft

A general view of the wing of the laboratory from the control platform at the head of the main flume is given in Fig. 3. This gives a good view of the main flume and the portion of the balcony floor in the wing. A portion of the first floor is also shown to the left of the main-flume wall.

Fig. 4 is a view of the first floor taken from the west end of the building. The concrete wall on the left is the south wall of the main flume. A vertical expansion joint and several window openings in this wall are shown clearly. The steel-plate flooring next to the flume wall covers the low-level return channel.

At the time of writing (March 24, 1932) the construction of the building has just been completed, and the installation of equipment is about to commence. Five pumps have been purchased (Nos. 2, 4, 5, 6, and 7, with capacities of 85, 10, 20, 5, and 16 cfs, respectively). The sluice gates for the discharge tank and the the 3-ft venturi-meter line have been delivered, and those for the 8-ft venturi-meter line and for one return channel are on order. The two cranes have been ordered, and bids are about to be sent out for the constant-level tank on the second floor and for a large part of the piping. Every effort is being made to provide immediately all equipment which is essential for the commencement of experimental work.

Markings on BULLETS *and* SHELLS *Fired From* SMALL ARMS[1]

By CHARLES O. GUNTHER[2]

A Study of the Engravings Made on the Cylindrical Portions of Bullets by the Lands and Grooves of Bores of Firearms, and of Breech-Block Imprints on Cartridge Cases and Firing-Pin Imprints on Primer Cups.

IN TWO articles entitled "Markings on Bullets and Shells Fired From Small Arms," appearing in the February and December, 1930, issues of MECHANICAL ENGINEERING, it was shown that a firearm adapted to fixed ammunition engraves its "signature" on the ammunition fired in it, one part of the "signature" appearing on the cartridge case and the other part on the bullet.[3] It is from this "signature" that the identification of the particular weapon is to be made. It has been shown that parts of this "signature" are subject to variations in the same weapon—one part of the "signature" which does not vary is the impression made by the breech block or recoil plate.

Methods analogous to those used to identify a particular typewriter[4] serve to identify a particular firearm. A brief outline of some of these methods and their applications in general follows.

For the purpose in hand it seems desirable to set up two classifications for firearms. In the first classification small arms are divided into two groups:

Group A. Small arms with smooth-bore barrels. In this group are found the various types of shotguns and the now obsolete types of smooth-bore weapons.

Group B. Small arms with rifled barrels. In this group are included weapons such as rifles, carbines, single-shot pistols, automatic pistols, revolvers, derringers, machine guns, etc.

Combination shotguns have one or two smooth-bore barrels in combination with another rifled barrel for use with a ball cartridge.

Originally the term "gage" as applied to the now obsolete types of smooth-bore weapons indicated the number in a pound of lead balls of the size adapted to the weapon. As applied to shotguns it indicated that the bore diameter was equal to the diameter of a lead ball whose weight in pounds was equal to the reciprocal of the gage index; e.g., the bore diameter of a 12-gage shotgun would be equal to the diameter of a lead sphere weighing one-twelfth of a pound.

The term "caliber" was also used to indicate the bore diameter of weapons with smooth-bore barrels which fired a lead ball; thus, caliber .50 indicated a bore diameter of 0.50 in. With the advent of rifling barrels the term was retained, and today it only approximately indicates the bore diameter of the weapon; e.g., a caliber .38 revolver of a certain make has a bore diameter of 0.36 in. The caliber may also be expressed in millimeters.

In the second classification, small arms are divided into four groups:

Group C. Small arms adapted to center-fire ammunition.

Group D. Small arms adapted to rim-fire ammunition.

Group E. Small arms adapted to pin-fire ammunition.

Group F. Small arms with flint locks or percussion locks.

PROBLEMS INVOLVED IN THE IDENTIFICATION OF FIREARMS

The science of identification of firearms concerns itself primarily with four types of problems:

I Given a discharged cartridge case, to determine the type and make of weapon in which it was discharged.

II Given a bullet, to determine the type and make of weapon from which it was fired.

III Given a discharged cartridge case and a suspected weapon, to determine whether or not the cartridge case was discharged in the suspected weapon.

IV Given a bullet and a suspected weapon, to determine whether or not the bullet was fired from the suspected weapon.

[1] A partial statement of results of a research being aided by Engineering Foundation. See previous articles in MECHANICAL ENGINEERING, February, 1930, pp. 107–113; and December, 1930, pp. 1065–1069.

[2] Lieutenant-Colonel, Ordnance Reserve, U. S. A. Consulting Engineer and Professor of Mathematics, Stevens Institute of Technology, Hoboken, N. J. Mem. A.S.M.E. Professor Gunther received his degree of M.E. from Stevens Institute in 1900, in which year he joined its faculty as an instructor. He was appointed to his present position in 1908. In 1918 and 1919 he was with the Ordnance Department of the United States Army, during which time he was closely associated with the experimental and development work in small arms and small-arms ammunition at Springfield Armory and at the Small-Arms Ballistic Station, Miami, Fla.

[3] The author has also made a careful analysis of the manufacturing operations involved in rifling, which brought out the great variety of factors influencing the markings on bullets fired from individual weapons.

[4] Osborn, in "Questioned Documents," second edition, pages 589–598, says: "Typewriting individuality in many cases is of the most unmistakable and convincing character, and reaches a degree of certainty that can properly be described as almost absolute proof. The identification of a typewritten document in many cases is exactly parallel to the identification of an individual who exactly answers a general description as to features, complexion, size, etc., and in addition matches a detailed list of scars, birthmarks, deformities, and individual peculiarities. The identification in either case is based upon a definite combination of common or class qualities and features in connection with a second group of characteristics made up of divergences from class qualities which then become individual peculiarities."

The solution of the first two types of problems must be based on *class* characteristics, whereas the solution of the latter two types of problems must be based on *accidental* characteristics.

All information relating to a firearm, which can be obtained or inferred from an examination of the drawings, specifications, schedules of operations, gages, jigs, and fixtures, will be classified under the head of class characteristics. Class characteristics are under the control of man.

Accidental characteristics of a firearm are those characteristics whose existence is beyond the control of man and which have a random distribution; their existence in a firearm is brought about through the failure of a tool in its normal operation, wear, corrosion, erosion, mutilation, and other fortuitous causes. Dimensional variations in class characteristics, whether within or outside of the tolerances allowed by the specifications, are accidental characteristics. Accidental characteristics are independent of class characteristics and exist in all firearms.

The solution of the first type of problem depends entirely upon the extent to which it is possible to establish class characteristics for the various types and makes of weapons in order to differentiate between them, keeping in mind that such class characteristics, to be of any value, must be recognizable from the deformations, impressions, and markings on the cartridge case.

It is a simple matter to determine the caliber of the weapon, and whether it belongs to group C, D, or E.

An examination of various types and makes of small arms indicates many possibilities for establishing class characteristics. For instance, we find differences in the design and construction of breech blocks and recoil plates. Automatic (auto-loading) pistols differ both in design and construction. Some manufacturers have adopted machining operations which are different from those used by other manufacturers in producing the breech-block surfaces, and it is therefore possible to determine the manufacturers of a certain class of weapons by the machining operation from an examination of the tool-mark pattern of the breech-block impression.

A study of the surfaces resulting from various machining operations enables one to recognize a particular machining operation by an examination of the tool-mark pattern on the surface. In Fig. 1 are photomicrographs ($\times$ 5.6) of the surfaces of pieces of cold-rolled steel showing the tool-mark patterns made by:

(*a*) A power-driven hack saw
(*b*) Fine and coarse files
(*c*) A grinding wheel
(*d*) A lathe tool
(*e*) A milling-machine cutter, and
(*f*) A shaper tool.

Other differences in the design and construction of automatic (auto-loading) pistols are apparent from an examination of the extractor, ejector, the surface brought in contact with the top of the base of the cartridge case in the process of forcing the cartridge out of the magazine into the chamber of the barrel, and the relative positions of the deformations and marks produced by these on the cartridge case.

In weapons in which the cartridges are loaded into magazines, the sharp edges of the magazine will produce marks on the cartridge cases, but such marks will not appear on cartridge cases of cartridges which have been placed directly into the chamber of the barrel. A cartridge case may carry a series of these magazine marks, depending upon the number of times the cartridge was loaded in and removed from the magazine.

A study of the various types of firing pins will develop further information for establishing class characteristics. In this connection we note the size and shape of the impressions made by firing pins in weapons adapted to rim-fire ammunition, and in weapons adapted to center-fire ammunition we note the type, diameter, and shape of the firing pin. In some weapons the firing pin strikes the primer in a direction parallel to the axis of the bore. In many revolvers the firing pin is an integral part of the hammer and may strike the primer in a direction considerably inclined to the axis of the bore. Let O be the center about which the hammer turns when released by the trigger pull, y the distance from O to point of firing pin, and z the normal distance from O to the plane of the base of the primer of the cartridge in the chamber; then the firing pin will strike the primer in a direction inclined to the axis of the bore by the angle of percussion, whose sine is z/y. The microscopic examination of a cast of the firing-pin impression in the primer cup will enable one to determine the type, diameter, and shape of the firing pin. Such a cast also offers possibilities for developing methods by which the angle of percussion may be determined.

Further data for developing class characteristics can be obtained from an examination of the size and shape of the impression made by the nose of the hammer in weapons adapted to rim-fire ammunition.

In general, then, all surfaces with which the cartridge case comes in contact in a weapon should be examined for possible clues to class characteristics; especially is this true in the case of a weapon whose action is partly or entirely automatic.

In the second type of problem we have to deal with weapons in group B, and for this group the following may be assumed as class characteristics:

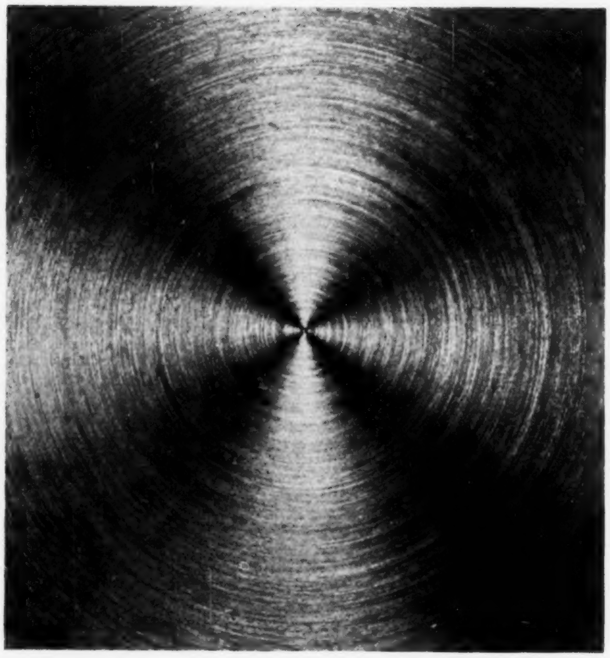
(*a*) Bore diameter
(*b*) Depth of grooves
(*c*) Direction of twist of rifling
(*d*) Pitch of rifling
(*e*) Number of grooves
(*f*) Width of grooves, and
(*g*) Width of lands.

A study and comparison of the specifications of many manufacturers, both American and foreign, indicates sufficient variation in these items to adopt them as class characteristics, and this adoption is made necessary by the fact that these items are the only ones in reference

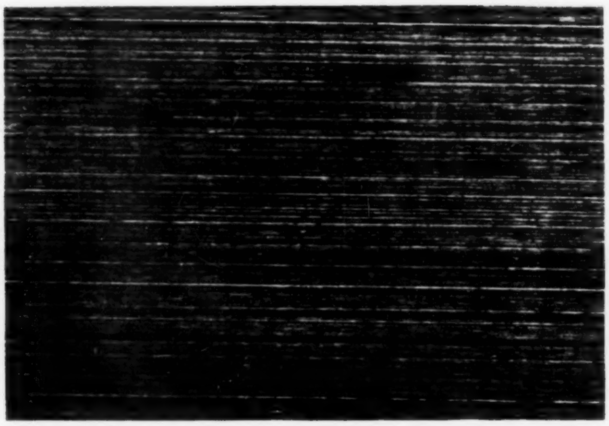
(*a*) Power-Driven Hacksaw

(*b*) Fine and Coarse Files

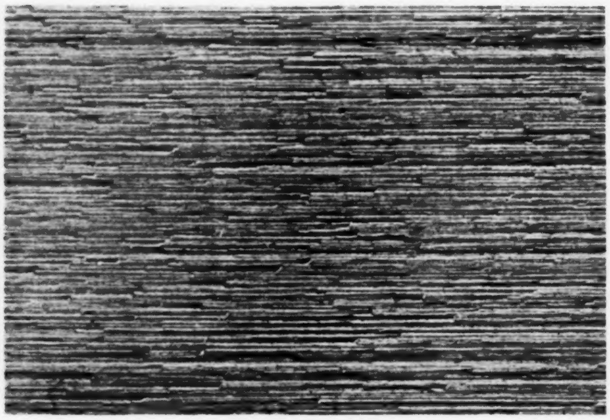
(*c*) Grinding Wheel



(*d*) Lathe Tool



(*e*) Milling-Machine Cutter



(*f*) Shaper Tool

FIG. 1 PHOTOMICROGRAPHS OF TOOL-MARK PATTERNS RESULTING FROM VARIOUS MACHINING AND HAND-TOOL OPERATIONS ON COLD-ROLLED STEEL ($\times$ 5.6)

to which we can obtain information from the bullet. In this connection it should be noted that certain manufacturers have in the past made changes in their specifications from time to time, and that manufacturers will continue to make changes in the future. The dimensions given in the specifications are subject to variations governed by the tolerances. If a bullet is not too much deformed and mutilated, it is possible to obtain by appropriate measurements made with precision instruments, some idea of the class characteristics of the particular weapon from which the bullet was fired and thus establish the identity of the possible manufacturers of such weapons.

PROBLEMS WHOSE SOLUTION IS BASED ON ACCIDENTAL CHARACTERISTICS

The solution of the third and fourth types of problems must be based on accidental characteristics as indicated in the following:

Form of evidence	Group	Probability of reproduction by other weapons
Accidental characteristics of:		
1 Impression of breech block or recoil plate...	C, D, and E	1 in *b*
2 Firing-pin impression..	C and D	1 in *f*
3 Impression of nose of hammer	D	1 in *b*
4 Extractor and ejector marks..............	A and B (arms with automatic ejection)	
5 Analysis of the engraving on the surface of the bullet..........	B	1 in *x*

The probability factors in the preceding tabulation must be established by research conducted by competent investigators.

Obviously not all firearms in existence can be examined for accidental characteristics, and therefore the science of identification becomes fundamentally a mathematical science in that it must determine from an examination of relatively small groups of firearms the probable distribution of accidental characteristics in the larger groups. The science of identification consequently has recourse to the laws of permutations and combinations, the theory of probability, and other mathematical rules—the same mathematical fundamentals which, in one form or another, find their application in practically every field of human endeavor.

To illustrate the use of the probability factors, suppose a cartridge case and a revolver of a certain make to have been recovered in connection with a crime, and that investigations indicate complete agreement of the recoil-plate and firing-pin impressions made by the revolver with those on the recovered cartridge case. Let us further assume that research has established for this particular type of revolver that $b = 1000$ and that $f = 500$, then the probability of the existence of another revolver of this type which would produce the same recoil-plate and firing-pin impressions would be 1 in 500,000.

1 *Impression of Breech Block or Recoil Plate.* A well-defined breech-block impression on the base of the cartridge case and primer cup is probably the most valuable form of evidence obtainable for the purpose of identifying the weapon in which the cartridge was fired, and especially is this true in the case of automatic pistols. The "pattern" of the impression remains fixed, and variations in the pressure developed by the powder gases do not affect it other than to make the impression more or less pronounced. The results of investigations conducted in Germany indicate that the coexistence of two automatic pistols producing identical breech-block impressions is very remote.

In *Chemiker-Zeitung* (1930), page 775, Dr. Otto Mezger says:[5] "Diese Spuren sind u. E. um deswillen noch beweiskräftiger als die Fingerabdrücke, weil es sich beim Stossboden um ein starres Material handelt, auf das der Patronenhülsenboden beim Rückstoss immer annähernd mit derselben Kraft aufgeschlagen wird."

2 *Firing-Pin Impression.* Firing-pin impressions on rim-fire ammunition are generally well defined and often show accidental characteristics under the microscope. Firing-pin impressions on center-fire ammunition are subject to variations with a corresponding distortion of pattern.

3 *Impression of Nose of Hammer.* The impression made by the nose of the hammer on rim-fire ammunition is generally well defined, and often shows accidental characteristics under the microscope.

4 *Extractor and Ejector Marks.* The relative positions of the extractor and ejector marks offer further confirmatory evidence in conjunction with the breech-block or recoil-plate and firing-pin impressions.

5 *Analysis of the Engraving on the Surface of the Bullet.* A study of the engravings on the surfaces of bullets actually fired from the suspected weapon made by comparing them under microscopes, must establish the existence of accidental characteristics in the barrel of the weapon, and the combination of these accidental characteristics must produce a probability factor of such magnitude as to preclude the existence of another weapon from which these bullets could have been fired. A similar study of the engraving on the surface of the fatal bullet in comparison with the engravings on the surfaces of the test bullets from the suspected weapon, must confirm the previously established accidental characteristics existing in the barrel.

The agreement of the class characteristics as indicated by the fatal bullet in comparison with test bullets from the suspected weapon only establishes the fact that the fatal bullet was fired from a weapon having the same class characteristics as the suspected weapon. The determination of the accidental characteristics which differentiate a particular weapon from all other weapons requires the knowledge, skill, and experience resulting from years of tedious study and hard work along scientifically directed lines. It is not simply a matching of lines as one might be led to believe from reading some

[5] "Ueber die Entwicklung der schiesstechnischen Untersuchungen sowie den Schartenspurennachweis bei Baumfrevel und Münzfälschungen," Von Dr. Otto Mezger, Direktor des Chemischen Untersuchungsamtes der Stadt Stuttgart. *Chemiker-Zeitung*, 1930, pp. 753, 774, 830, and 851.

of the articles which have appeared at times in popular magazines. For example, Fig. 2 shows photomicrographs (× 5.6) of the corresponding surfaces of two bullets from cartridges taken from the same box of ammunition and fired in the same revolver, while Fig. 3 is a photomicrograph (× 15) showing how these two bullets "match."

The science of identification of firearms in all its ramifications covers a wide field and offers many interesting problems to the scientist. In the hands of competent persons it is capable of producing evidence of the highest order of credibility and of inestimable value to those engaged in the investigation of crimes and the prosecution of criminals. It is therefore strange that so little has been done in this country to develop the science to the degree of perfection it so well merits. The identification of handwriting, typewriting, and the like often plays an important part in cases in which the stakes are very high in that they involve large sums of money; on the other hand, the identification of firearms plays a part in cases where no such high stakes are involved—merely human life.

It is hoped that this brief outline, incomplete as it is, will nevertheless convey to the judges of our courts a clearer idea of what constitute pertinent qualifications of an expert, and so prevent the introduction of much of the crude and amateurish testimony which has heretofore found its way into our courts, and thereby strengthen the confidence which should rest in the science.

There is still a vast amount of work to be done in this country and which can only be accomplished by the cooperative efforts on the part of many trained investigators.

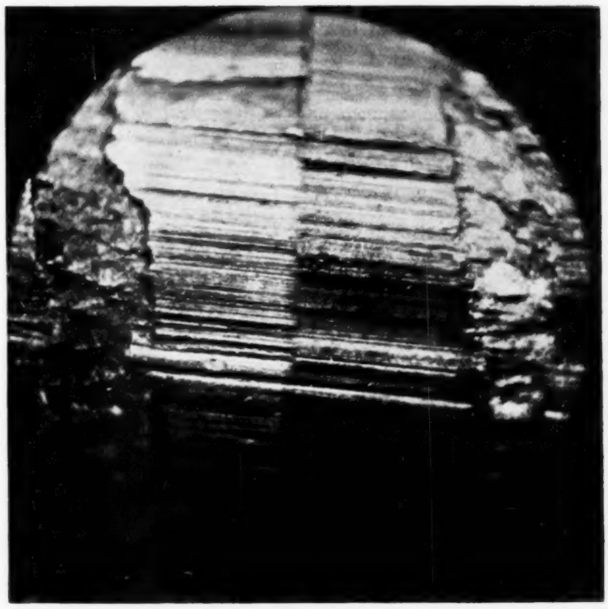


FIG. 3 PHOTOMICROGRAPH SHOWING HOW THE TWO BULLETS SHOWN IN FIG. 2 "MATCH" (× 15)

If a man will begin with certainties, he shall end in doubts; but if he will be content to begin in doubts, he may end in certainties.—FRANCIS BACON.

FIG. 2 PHOTOMICROGRAPHS OF THE CORRESPONDING SURFACES OF TWO BULLETS FROM CARTRIDGES TAKEN FROM THE SAME BOX OF AMMUNITION AND FIRED IN THE SAME REVOLVER (× 5.6)

PERFORMANCE OF A LARGE BLOWING ENGINE

IN THE converting of matte produced in the smelting of copper ores and concentrates a great deal of air at about 14 lb pressure is required. Hence it is important that converter blowing engines be efficient. In the particular case under consideration the reciprocating type of blowing engine was selected, as the best guarantee obtained from manufacturers of turbo-blowers had a water rate 4 per cent higher than that of the engine ordered at full load and 20 per cent higher at half-load.

During July, 1931, a final test was made at the Garfield, Utah, plant of the American Smelting and Refining Company on a blowing engine with a capacity of 30,000 cfm built by the Nordberg Manufacturing Company. The engine was bought with a guarantee that it would require not to exceed 0.99 lb of steam per 100 cu ft of free air compressed to 14 lb gage, steam to be at 150 lb gage and to have 100 F superheat. The elevation at Garfield is 4200 ft. The order provided that after erection the engine was to be tested in accordance with the A.S.M.E. test code. The test showed that the water rate was better than the guarantee by 9.6 per cent at half-load and by 3.5 per cent at full load.

This test is thought to be of interest to mechanical engineers as the author has no knowledge of previous tests of blowing engines of such size made under the rigid A.S.M.E. code. The nozzle of the test tank was larger than given in any published data available.

TESTS OF BLOWING ENGINE

	1/2 load	3/4 load	full load
Speed			
Total revolutions	2402	3565	4891
Average rpm	40.0	59.4	81.5
Average piston speed, ft per min.	360	534	734
Power			
Total steam ihp	751.4	1159	1695
Total air ihp	721.6	1122	1625
Horsepower required to adiabatically compress air delivered to discharge pressure of test, no clearance	666	989	1376
Economy Results			
Steam rate per ihp from engine exhaust, lb	10.000	9.967	9.960
Steam rate per ihp from jackets (reheat coil)	0.499	0.414	0.418
Total lb steam per ihp-hr	10.499	10.381	10.378
Steam ihp per 100 cu ft of free air delivered	0.0867	0.0898	0.0947
Total lb steam per 100 cu ft of free air under test conditions	0.9102	0.9321	0.9831
Total lb steam per 100 cu ft of free air corresponding to conditions of guarantee	0.8945	0.9114	0.955
Efficiency Results	Per cent		
Volumetric efficiency, actual, from nozzle measurements	89.2	89.5	90.3
Volumetric efficiency, from indicator cards	93.0	93.6	93.6
Compression efficiency, adiabatic no clearance	92.4	88.2	84.6
Mechanical efficiency (ratio of ihp from air cards to ihp from steam cards)	96.0	96.9	95.9
Overall efficiency (comp. eff. × mech. eff.)	88.6	85.4	81.2

All previous engines of this type owned by the smelting company had been tested by means of indicator diagrams only. In the present case the use of a nozzle was decided upon because of the many inaccuracies inherent in air measurement from an indicator diagram. As shown under "Efficiency Results" in the accompanying tabulation, the volumetric efficiency obtained by indicator diagram was from 3 to 4 per cent greater than that by nozzle measurement.

The engine is a cross-compound condensing machine with steam cylinders 28 in. and 64 in. in diameter × 54 in. stroke, and with air cylinders 65 in. in diameter × 54 in. stroke. The steam valves are of the releasing Corliss type and the air valves of the automatic plate type, that is, having a large number of long, narrow steel strips mounted on plugs. The engine is provided with an independent surface condenser, and during the test the steam from the engine exhaust was condensed therein and weighed in calibrated weigh tanks. The air delivery was measured by means of a gaging tank and nozzle, the tank being 9 ft 6$^3/_4$ in. in diameter × 20 ft long. The inlet pipe was provided with straightening vanes, and a baffle was placed inside the tank in front of the inlet. The discharge nozzle was 17 in. in diameter, made of cast iron and turned smooth.

The receiver ahead of the gaging tank was built above the air cylinders of the engine, and the total receiver volume, including that of a length of 30-in. pipe between the receiver and tank, was 1066 cu ft.

The air flow was calculated by means of a formula proposed by Dr. Sanford A. Moss and given in Trans. A.S.M.E., Vol. 50 (1928), namely,

$$q_3 = \frac{2.552 D^2 c T_3}{p_3} \sqrt{\frac{Bi}{T_1}}$$

where q_3 = cubic feet of air flowing per minute at pressure p_3 and temperature T_3, the conditions at the compressor inlet

D = diameter of the smallest part of the nozzles throat, in inches

c = coefficient of discharge—for this nozzle assumed to be 0.99

T_1 = absolute fahrenheit temperature, upstream side of nozzle

T_3 = absolute fahrenheit temperature of air at the compressor intake

p_1 = absolute pressure, pounds per square inch, upstream side of nozzle

p_2 = do., downstream side of nozzle

p_3 = do., at compressor intake

B = value p_2 expressed in inches of mercury. This corresponds to the corrected barometer reading

i = differential pressure ($p_1 - p_2$), i.e., the pressure drop through the nozzle, expressed in inches of water column.

The coefficient of discharge used by the smelting company in making the report, as noted above, was 0.99. The Nordberg engineers contended that the paper by Dr. Moss sanctions a coefficient of 0.995. If the latter figure is used the volume of air delivered will be increased proportionately and the steam rates will be better than that guaranteed by 3.9, 8.5, and 10.2 per cent, respectively, at full, three-quarters, and half-load. It is quite possible that the higher figure for the coefficient of discharge is allowable.—N. L. Stewart, Asst. Chief Engr., American Smelting & Refining Co., Garfield, Utah (Mem. A.S.M.E.), in a paper before the Utah Section of the A.S.M.E., Salt Lake City, Utah, October 9, 1931.

The Basic Laws and Data of HEAT TRANSMISSION[1]

By W. J. KING[2]

III—FREE CONVECTION

GENERAL MECHANISM

When the fluid in contact with the surface of a hot body is heated it becomes lighter and is displaced upward by the pressure of the surrounding denser fluid, carrying away heat in the streams of warm fluid or "convection currents" thus produced. If the surface is colder than the fluid, the process is reversed, but the same general laws and formulas apply in either case. This process is called free or natural convection. If the fluid is a liquid, the convection currents normally dissipate all of the heat lost by the surface, but if it is a gas the exchange of radiant heat between the body and the surrounding surfaces must be taken into account in computing the total dissipation. It is sometimes convenient to include both radiation and convection in expressing the total heat loss from a surface in still air, but since these processes are governed by different laws they should generally be computed separately.

The temperature and velocity distributions in the air streams over a vertical hot surface have been studied experimentally

FIG. 1 TEMPERATURE AND VELOCITY FIELDS IN THE AIR OVER A HEATED VERTICAL PLATE (FROM SCHMIDT)

by Griffiths and Davis,[3] Nusselt and Jurges,[4] Schmidt,[5] and Schmidt and Beckmann.[6] The curves of Fig. 1, from Schmidt's paper, are typical of the results obtained by all of these investigators. These curves show very plainly what happens in the air moving over a heated surface. The measurements were made along a normal to the surface, at various heights (Y) above the lower edge of the plate.

The significant facts to be observed are these:

1 The velocity immediately at the surface is always zero, increasing to a maximum at a distance of 2 or 3 mm, after which it falls off rapidly.

2 The velocity increases rapidly along the height of the plate. Tests on taller plates show that the velocity does not go on increasing indefinitely, but reaches a limiting value, depending upon the total height and temperature rise of the surface, beyond a distance of about 40 cm (16 in.) above the lower edge.

3 It can be deduced from the velocity curves that the air streams do not move altogether vertically over the plate, but are drawn in diagonally. Schmidt and Beckmann have shown mathematically that the flow lines at some distance from the plate must be nearly horizontal, turning upward sharply near the surface. Smoke tests in the laboratory have shown that a hot surface generally tends to draw in air streams laterally at the bottom, with the flow lines becoming nearly diagonal at the top.

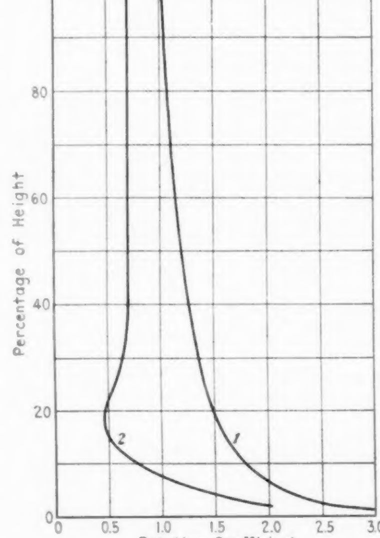


FIG. 2 VARIATION OF HEAT-TRANSFER COEFFICIENT ALONG THE HEIGHT OF A VERTICAL PLANE SURFACE AT A UNIFORM TEMPERATURE

Curve 1 (from Nusselt and Jurges): Height = 1.64 ft.
Curve 2 (from Griffiths and Davis): Height = 9 ft.

4 The temperature gradients are steep and straight near the surface. The slope is steepest near the bottom edge, and rapidly approaches a constant value at higher levels.

5 The air flowing over the upper portions of the plate has been warmed from below, so that its capacity for absorbing heat from the surface has been reduced. It is for this reason that a surface of short vertical height loses much more heat per unit area by convection than a tall one.

Fig. 2 shows how the heat-transfer coefficient at any point on a vertical surface varies with the distance above the lower edge. Curve 1 is typical of the results obtained by several observers for surfaces under 2 ft in height. The indications

[1] Part I, a general survey of the subject, appeared in the March issue, pp. 190–194, and Part II, on Conduction, in the April issue, pp. 275–279.

[2] Engineering General Department, General Electric Company, Schenectady, N. Y.

[3] E. Griffiths and A. H. Davis. "The Transmission of Heat by Radiation and Convection." Special Report No. 9, Food Investigation Board, H. M. Stationery Office, London, 1922. (Revised Ed. pub. 1931.)

[4] W. Nusselt and W. Jurges. *Zeit. V.D.I.*, vol. 72 (1928), p. 597.

[5] E. Schmidt. *Zeit. für die gesamte Kælte-Industrie*, vol. 35 (1928), p. 213.

[6] E. Schmidt and W. Beckmann. *Technische Mech. und Thermo.*, vol. 1, no. 10, p. 341, and no. 11, p. 391, 1930.

are that the air flow is streamline or laminar in character. This curve also represents the relative magnitudes of the average coefficients for short surfaces of various heights. Thus if the height of a surface is reduced to 20 per cent of its original value, it will lose 50 per cent more heat per unit area by convection; or if the height is reduced to 7 per cent, the coefficient will be doubled. On the other hand, for tall surfaces (curve 2) the coefficient has a high value at the lower edge, which decreases to a minimum at something like 17 per cent of the total height. Apparently at this point turbulence begins to develop in the air streams, so that the coefficient is increased for a short distance, after which it reaches a constant value which is maintained up to the top of the surface.

The occurrence of turbulence in the convection currents along a tall surface was noted by Koch,[7] in his studies of the heat loss from pipes in air. The effects of these transitions in the air streams over a surface are shown graphically by the curves of Fig. 3, from Koch's tests on a vertical tube, heated electrically by a uniformly wound internal-resistance heater. These

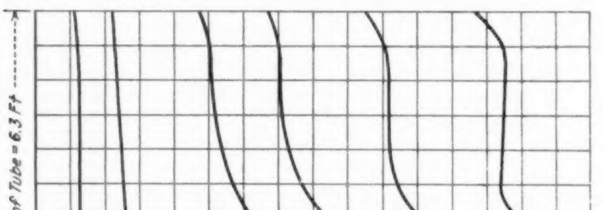


FIG. 3 TEMPERATURE RISE OF 1.22-IN.-DIAM. ELECTRICALLY HEATED VERTICAL STEEL TUBE IN AIR (FROM KOCH)

curves show that the conduction of heat along the steel tube was not sufficient to equalize the differences in local temperatures due to the unequal rates of convective cooling at various levels. Koch found that at the higher temperatures the turbulence became so pronounced that eddies were detached from the air streams, and the tube temperatures sometimes fluctuated periodically. This sort of instability in fluid flow has been observed in other cases of free convection, and probably explains some of the discrepancies in the data reported by different observers for apparently the same conditions.

FILM THEORY

Referring again to Fig. 1, since the velocity at the surface is zero, all of the convected heat must first be transmitted across the air film immediately in contact with the surface by pure conduction. Thus the rate of heat flow per unit area at any point must be equal to the product of the conductivity (k) of the air and the temperature gradient where $x = 0$, if x is the distance along the normal. Thus,

$$\frac{q}{A} = k\left[\frac{\partial t}{\partial x}\right]_{x=0} \qquad [1]$$

Suppose that it is assumed that the temperature gradient is a straight line all the way from the surface, where the temperature is t_s, to a point at a distance x_1, where the temperature is that of the ambient air, t_a. The equivalent of Equation [1] then becomes

$$\frac{q}{A} = k\,\frac{t_s - t_a}{x_1} \qquad [2]$$

In other words, the convection from any surface may be expressed in terms of the equivalent conduction through a stagnant air film of thickness x_1, across which the entire temperature drop occurs. This is the "film theory," developed by Langmuir[8] and Rice[9] before any measurements of the actual temperatures and velocities had been made. The thickness of this equivalent film (x_1) as calculated by these authors was about 5 mm for plane surfaces.

There are two arguments against the continued use of this theory: (1) The calculation is rendered more cumbersome because it is first necessary to calculate the film thickness and then substitute it in Equation [2] to get the rate of heat flow; and (2) it does not properly describe the actual mechanism of the process. Actually, the greater part of the heat is carried away by the convection streams within the "film" formerly regarded as stagnant. On the other hand, there are several significant facts, brought out by Langmuir and Rice, which make the film theory a real contribution: (1) The convection from a large plane surface may be calculated with a fair degree of accuracy over a wide range of temperature in terms of the conduction through a film having a constant thickness of about 5 mm, at atmospheric pressure, if the variation of the conductivity of the air with the temperature is taken into account. (2) In the case of wires and cylinders, in any fluid, a logarithmic plot of the data results in a straight-line function for the film thickness in terms of the variables involved. In this case the logarithmic mean area of the cylindrical film must be substituted for A in Equation [2]. As will be shown later, a similar plot for the surface heat-transfer coefficient (h) results in a curved line, so that h cannot be expressed as a single exponential function of the variables. (3) The concept of conduction through a stagnant fluid film makes it easier to visualize the complex mechanism of convection in terms of a simple equivalent process. However, the film theory will be abandoned for the present purpose because of the two objections mentioned above, although the work of Rice remains one of the best analyses of the general problem, and many of his formulas are reduced to more convenient forms.

UNITS

One of the most awkward factors in the entire field of heat transmission is the matter of units. Particularly in dealing with convection, almost no two authors use the same system of units for all the variables. While it is very desirable to use convenient and familiar units, it is equally desirable to use a consistent system, in which all of the units are expressed in terms of a single set of fundamental dimensions. In such a system the data may usually be correlated as functions of dimensionless groups or moduli, so that the results obtained apply equally well in any other consistent set of units. Unfortunately, no system of engineering units can be found which is both convenient and consistent. The following units were adopted for the present purpose because they are consistent and because most of them are convenient:

---

[7] W. Koch. "Ueber die Wärmeabgabe geheizter Rohre bei verschiedener Neigung der Rohrachse." Beihefte zum *Gesundheits-Ingenieur*, Reihe 1, Heft 22. R. Oldenbourg, Munich, 1927.

[8] I. Langmuir. *Phys. Rev.*, vol. 34 (1912), p. 401.

[9] C. W. Rice. Trans. A.I.E.E., vol. 42 (1923), p. 653; vol. 43 (1924), p. 131. Int. Crit. Tables, vol. 5 (1929), p. 234.

h = surface heat-transfer coefficient, $\frac{\text{Btu}}{(\text{hr})(\text{sq ft})(\text{F})}$

L = characteristic linear dimension of body (diameter of wire, height of plane), feet

k = conductivity of fluid, $\frac{\text{Btu}}{(\text{hr})(\text{sq ft})(\text{F/ft})}$

ρ = density of fluid, lb/cu ft

β = coefficient of thermal expansion of fluid $\left(\frac{1}{\rho}\ \frac{\partial\rho}{\partial t}\right)$, 1/F

μ = viscosity of fluid, $\frac{\text{lb}}{(\text{hr})(\text{ft})}$

θ = temperature rise of surface over main body of fluid, F

c_p = specific heat of the fluid (at constant pressure for a gas), $\frac{\text{Btu}}{(\text{lb})(\text{F})}$

g = acceleration of gravity, ft/hr^2 (4.17×10^8)

The following factors are given for converting from convenient units:

Divide k in Btu per hr per sq ft per deg F per inch by 12 to get k as above.

Multiply μ in cgs units, or poises, by 242 to get μ as above.

The properties of the fluid should be taken at the average of the surface and main fluid temperatures. For gases, the value of β will be approximately $1/T_m$, where T_m is the average temperature in deg F absolute.

GENERAL FORMULAS

The fundamental equations for the general problem of free convection have also been studied by Nusselt[10,11] Davis,[12] Fishenden and Saunders,[13] and others. Because of the difficulties inherent in a direct integration of the general differential equations of hydrodynamics and heat flow, the solution has generally been obtained by some other method, such as the transformation of coordinates, the principle of similitude, or dimensional analysis. The result is usually reducible to the form

$$B = F(M)\,f(N) \qquad [3]$$

where B, M, and N are dimensionless moduli as follows:

$$B = \frac{hL}{k}$$

$$M = \frac{\rho^2 g\beta L^3 \theta}{\mu^2}$$

and

$$N = \frac{\mu c_p}{k}$$

Although the functions F and f are not necessarily the same, it has been shown both theoretically and by correlations of the experimental data that, as a reasonable approximation, Equation [3] may be expressed in the form

$$B = F(MN)$$

or

$$\frac{hL}{k} = F\left(\frac{\rho^2 g\beta c_p L^3 \theta}{\mu k}\right) \qquad [4]$$

In the preceding article of this series, on Conduction,[14] it was shown that the conductivity of a gas is related to its viscosity and specific heat at constant volume as follows:

$$k = \epsilon\mu c_v \qquad [5]$$

where ϵ is a constant depending upon the number of atoms in the molecule. Since the ratio of the two specific heats

$$\gamma = \frac{c_p}{c_v}$$

also depends on the number of atoms, the value of the modulus N can be determined for each type of gas by substituting in Equation [5], as shown below:

No. of atoms	ϵ	γ	$\frac{\gamma}{\epsilon} = \frac{\mu c_p}{k} = N$
1	2.45	1.66	0.68
2	1.90	1.40	0.74
3	1.70	1.27	0.75
More than 3	1.30	1.28	0.98

Since N is practically a constant for most of the common gases, B is usually expressed as a function of M alone, when the discussion is limited to gases. This constant relationship between k, μ, and c_p also makes it possible to substitute for any one of these factors in terms of the other two, so that formulas for both free and forced convection in gases may be expressed in several equivalent forms, which at first appear irreconcilable.

In the case of liquids, the value of N may vary over a wide range, so that it must be included, as in Equation [4], in any general treatment of both gases and liquids.

The form of the function F can be determined by plotting experimental data for B against MN. It is to be expected that this function will have a definite form only for data obtained under strictly similar conditions, i.e., for bodies of similar geometrical shape and for similar types of fluid flow, as long horizontal wires and cylinders immersed in any fluid in streamline flow. However, the differences between these individual functions are less than the differences in the various data reported for a single case. For this reason the author has plotted some of the data for several different cases in a single correlation, as shown in Fig. 4. The symbol a is used to represent the fluid properties involved in the modulus MN, and its value is given in Fig. 5 for air and Fig. 6 for alcohol, water, and transformer oil, as a function of the average fluid temperature. It should be noted that a has the dimensions $1/(\text{ft}^3 \times \text{F})$, whereas the quantities plotted in Fig. 4 are dimensionless and have the same values in any consistent system of units.

The curve of Fig. 4 was derived from correlations for horizontal wires and cylinders in various gases and liquids by Nusselt,[11] and for horizontal wires and cylinders in several gases, and vertical planes in air, by Fishenden and Saunders.[13] It is supported by several hundred points, computed from the data reported by a score of observers, which are omitted here to avoid overloading the figure. The points shown were computed mostly from data which have not previously been correlated in this manner. The data of Griffiths and Davis,[3] represented by the open circles, were added to call attention

[10] W. Nusselt. *Gesundheits-Ingenieur*, vol. 38 (1915), pp. 477 and 490. (See also ref. 4.)

[11] W. Nusselt. *Zeit. V.D.I.*, vol. 73 (1929), p. 1475.

[12] A. H. Davis. Nat. Phys. Lab., Collected Researches; "The Convection of Heat in Gases and Liquids." I–VII. (Reprint of papers XI–XVII, Vol. XIX, 1926.) Or see: *Phil. Mag.*, vol. 44 (1922), p. 921.

[13] M. Fishenden and O. A. Saunders. *Engineering*, Aug. 8, 1930, p. 177 and Aug. 15, p. 193.

[14] MECHANICAL ENGINEERING, vol. 54, April, 1932, pp. 275–279.

to the probable error in some of their widely used results for vertical cylinders in air. These refer to tests on a series of cylinders about 7 in. in diameter and ranging from 1.83 in. to 8.8 ft in height. The ends were capped with disks of insulating brick about 3 in. thick, and of the same diameter as the cylinder. These caps apparently had a negligible effect on the heat loss from the taller tubes, but the end effects which they introduced probably account for the considerable dis-

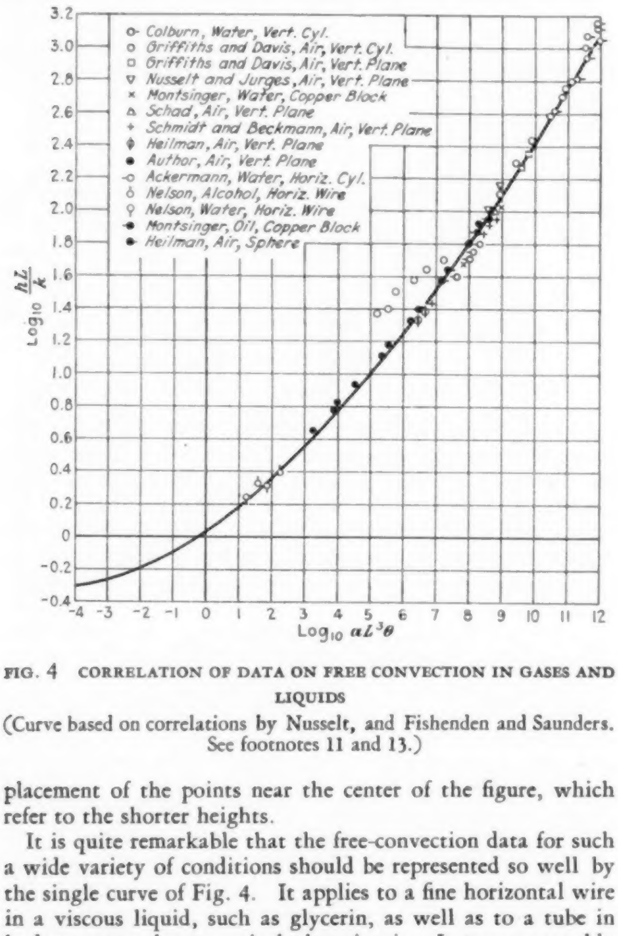


FIG. 4 CORRELATION OF DATA ON FREE CONVECTION IN GASES AND LIQUIDS

(Curve based on correlations by Nusselt, and Fishenden and Saunders. See footnotes 11 and 13.)

placement of the points near the center of the figure, which refer to the shorter heights.

It is quite remarkable that the free-convection data for such a wide variety of conditions should be represented so well by the single curve of Fig. 4. It applies to a fine horizontal wire in a viscous liquid, such as glycerin, as well as to a tube in hydrogen or a large vertical plane in air. It may reasonably be assumed that this curve can be used to obtain the approximate value of the heat-transfer coefficient (h) for any type of free-convection problem, so long as the fluid flow is not restricted or impeded. It does not apply to convection in narrow gaps or ducts, or from large horizontal surfaces, particularly a warm surface facing downward.

It is probable that if more accurate data were available several curves could be plotted, similar in shape but spaced a small distance apart. The curve for horizontal cylinders would probably lie slightly below that for vertical planes, and the curves for streamline and turbulent flow might be distinguished. However, this hardly seems worth while until more complete and reliable information is available.

The factor L, which is contained in both of the quantities plotted in Fig. 4, was defined above as the characteristic linear dimension of the body (in feet, in the present units). This refers to the diameter of a long wire or cylinder, or the height of a long vertical plane. It has been quite definitely established that any dimension, either horizontal or vertical, greater than about 2 ft has a negligible effect on the unit heat loss from a body, and in the case of a pipe the effect of increasing the diameter beyond 6 or 8 in. is very small. However, when there is reason to expect that both the horizontal and vertical dimensions may affect the convection rate, as in the case of small short cylinders, planes, or spheres, the characteristic dimension may be obtained from the expression

$$\frac{1}{L} = \frac{1}{L_{\text{horiz.}}} + \frac{1}{L_{\text{vert.}}} \quad \text{[6]}$$

(For a sphere L = radius.) This implies that the horizontal and vertical dimensions have the same effect, which may not be strictly true, but it will be found that this expression gives very satisfactory results.

For the higher values of $aL^3\theta$, the curve of Fig. 4 has a slope of $^1/_3$. This means that Equation [4] can be written in the form

$$\frac{hL}{k} = C_1(aL^3\theta)^{1/3} \quad \text{[7]}$$

The value of the constant C_1 is 0.13, so that the formula for large surfaces of any shape in any fluid is

$$h = 0.13\, ka^{1/3}\theta^{1/3} \quad \text{[8]}$$

Further down on the curve the slope is continually changing, which means that it is not possible to write a single exponential formula for the heat-transfer coefficient when the latter is affected by the size of the body. However, over a limited range of the variables the slope is nearly constant, so that an approximate equation can be written for any part of the curve. A number of practical cases of free convection fall in the range

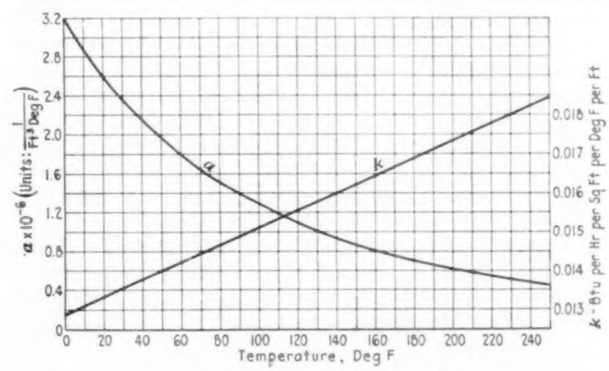


FIG. 5 VALUES OF THE MODULUS $a = \rho^2 g\beta c_p/\mu k$ AND CONDUCTIVITY k FOR AIR

(For pressures other than atmospheric, multiply a by the square of the pressure in atmospheres. k is independent of the pressure.)

of sizes from $^1/_2$ in. to 2 ft, at moderate temperatures, where the average slope is $^1/_4$. In this region the general formula is

$$h = \frac{0.55\, ka^{1/4}\theta^{1/4}}{L^{1/4}} \quad \text{[9]}$$

For gases, a is proportional to the square of the pressure, except at very high or low pressures. In the range of variables covered by Equation [9], the free-convection coefficient is therefore proportional to the square root of the pressure.

At its lower end the slope of the curve of Fig. 4 approaches zero, or log (hL/k) approaches a constant value of about —0.35. Thus, if L = diameter (d), the heat-transfer coefficient for very fine wires and small temperature rises approaches the limiting value

$$h = 0.65\,\frac{k}{d} \qquad [10]$$

SPECIFIC FREE-CONVECTION DATA AND FORMULAS

1 Large Surfaces in Air

Although there are considerable discrepancies in the data reported, an average value of the free-convection coefficient for large vertical surfaces, such as walls, windows, pipes, etc., in atmospheric air, may be obtained from the formula

$$h = 0.22\,\theta^{1/3} \text{ Btu per hr per sq ft per deg F} \qquad [11]$$

Or if H is the heat transferred per unit time per unit area:

$$H = 0.22\,\theta^{4/3} \text{ Btu per hr per sq ft} \qquad [12]$$

According to Griffiths and Davis' results,[3] the constant in these formulas will be about 27 per cent greater for a horizontal surface facing upward, and 33 per cent less facing downward.

2 Surfaces of Medium Size in Air

(*a*) *Plane Surfaces*. In the absence of adequate data to indicate the effect of height on the convection coefficient for vertical

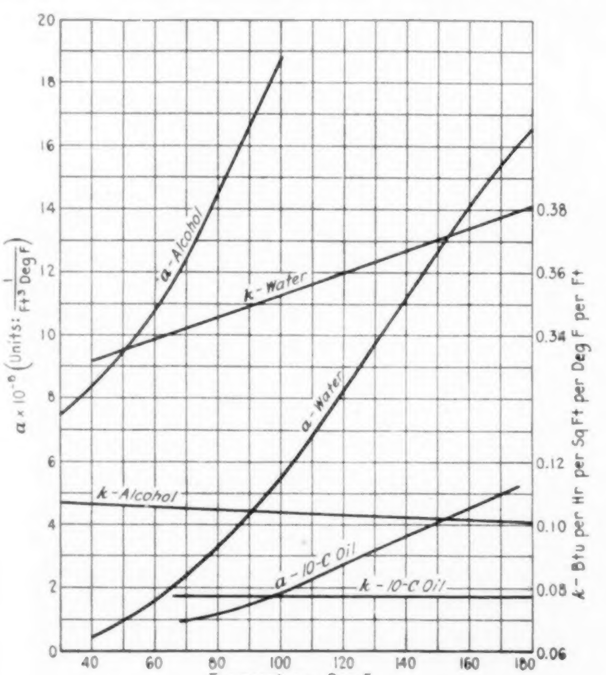


FIG. 6 VALUES OF THE MODULUS $a = \rho^2 g\beta c_p/\mu k$ AND k FOR ETHYL ALCOHOL, WATER, AND TRANSFORMER OIL AT VARIOUS TEMPERATURES

planes, some writers have used Griffiths and Davis' data for a vertical 7-in. pipe in the range of heights from 1.83 to 11.3 in. Since these data did not agree with some of the results of Heilman,[15] Langmuir,[8] and Schmidt,[6] and the points computed from them fell too far above the curve of Fig. 4, the author recently carried out a series of tests to check them. The test units were made up of strips of 1-mil aluminum foil, $^1/_2$ in. wide and 3 ft long, cemented to both sides of a strip of 64-mil sheet asbestos. Four such strips were constructed and mounted so that the horizontal length was 3 ft and the vertical heights were $^1/_2$, $1^1/_2$, 3, and 12 in., corresponding respectively to 1, 3, 6, and 24 strips of foil, separated by small gaps, on each side of the asbestos. The strips were independently heated by electric currents, which were controlled by separate rheostats adjusted to bring each strip to the same temperature. The power required per strip followed curve 1 of Fig. 2 very closely. The temperatures were measured by three different methods: (1) change in resistance of the (calibrated) aluminum strips, (2) thermocouples embedded in the asbestos between pairs of strips, and (3) compensated thermocouple which could be moved over the external surface. After correcting for the small amount of radiation from the polished aluminum, the results represented by the curves of Fig. 7 and the closed circles in Fig. 4 were obtained.

It will be found that over the range of temperatures covered by Fig. 5, the product $ka^{1/4}$ for air has a nearly constant value

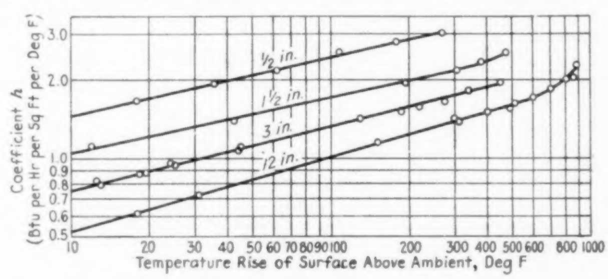


FIG. 7 FREE-CONVECTION COEFFICIENTS FOR VERTICAL PLANE SURFACES OF VARIOUS HEIGHTS, IN AIR AT 70 F

of about 0.5, at atmospheric pressure. Substituting this in Equation [9], the formula for vertical planes up to two or three feet in height, in air, becomes

$$h = 0.275\sqrt[4]{\frac{\theta}{L}} \text{ Btu per hr per sq ft per deg F} \qquad [13]$$

or

$$H = 0.275\,\frac{\theta^{5/4}}{L^{1/4}} \text{ Btu per hr per sq ft} \qquad [14]$$

where L is the height in feet. For pressures other than atmospheric it is necessary merely to multiply by the square root of the pressure in atmospheres. Various observers do not agree on the effect of orientation of the plane, which seems to depend upon the size, but as a rough average it may be said that the convection from a horizontal surface facing upward is about 30 per cent greater, and facing downward 30 per cent less, than in the vertical position.

(*b*) *Cylindrical Surfaces*. A considerable number of unusually consistent data from various sources indicate that the free convection from horizontal pipes in air may be obtained from the formula

$$h = 0.23\sqrt[4]{\frac{\theta}{L}} \text{ Btu per hr per sq ft per deg F} \qquad [15]$$

which also varies with the square root of the pressure in atmospheres. For long pipes L is the diameter in feet; if the end effects may be considerable, its value can be obtained from Equation [6]. Formula [15] applies to diameters ranging from about $^1/_4$ in. to 1 ft.

Although Koch[7] has shown that the convection from vertical pipes may be affected considerably by the production of turbulence and eddies in the air streams, his results and others show that in general the coefficient is about the same in either the horizontal or vertical position.

Additional information on the heat loss from wires and

[15] R. H. Heilman, MECHANICAL ENGINEERING, vol. 51, May, 1929, p. 355.

pipes will be found in the works of Rice,[9] Heilman,[15] Griffiths and Jakeman,[16] Eberle,[17] and Houghten and Gutberlet.[18]

(*c*) *Air Ducts or Channels.* Schmidt[5] has shown that when two vertical parallel plates 6 in. square, heated to the same temperature, are brought together the convection coefficient is first affected at a separation of about $1/2$ in. As the spacing is reduced further, the convection rapidly falls off, until at a separation of $1/8$ in. the heat loss from the duct surface has been reduced practically to zero. Similar results were obtained by the author[19] with somewhat larger plates.

(*d*) *Enclosed Air Spaces.* The most complete work on the subject of heat transfer across enclosed air spaces is reported in a recent paper by Mull and Reiher.[20] The papers by Nicholls,[21] Rowley and Algren,[22] Schad,[23] Queer,[24] and Gregg[25] also contain valuable data. A recent article by Beckmann[26] contains an excellent discussion of heat transfer in cylindrical gas layers.

This subject is too involved to allow a complete discussion here, but some of the significant facts may be stated as follows:

1 In vertical spaces of widths greater than $3/4$ in., the convection is practically independent of the width, and is equal to about one-half the value obtained from formula [13] if θ is taken as the temperature difference between the two surfaces.

2 In narrower spaces the convection falls off rapidly, until it is completely suppressed at a separation of $1/8$ in. However, in narrow spaces, the pure conduction through the gas becomes very considerable, and the radiation is independent of the spacing, so that for a single air space the minimum total heat transfer is usually obtained at a width of about $3/4$ in.

3 The effect of height is about the same as for exposed surfaces. Queer [24] finds that the convection across a space $4^1/_2$ in. high is about 80 per cent greater than for a height of 35 in.

4 In a vertical air space at a mean temperature of 60 F, greater than $1/2$ in. in width, the combined heat-transfer coefficient for all three processes usually runs about 1.2 Btu per hr per sq ft per deg F for surfaces of ordinary building materials, and about 0.35 for bright metallic surfaces, which reduce the radiation.

5 If a single wide air space is subdivided into a number of narrow spaces in series, although the coefficient for each individual space may be increased, the total overall or series heat-transfer coefficient will be reduced, because of the series effect and the suppression of convection. Hence when air spaces are used for thermal insulation, the most effective results are obtained by using several layers separated by foil or thin sheets of bright metal, spaced about $1/8$ or $1/2$ in.

FREE CONVECTION IN LIQUIDS

Very few data on free convection in liquids have been published. Davis[12] reports some tests on wires in toluene, CCl_4, aniline, olive oil, and glycerin; Nelson[27] on wires in water, alcohol, CCl_4, glycerin, and castor oil; Colburn and Hougen[28] on water in a vertical pipe, and Ackermann[29] on a short, horizontal 2-in. pipe in water.

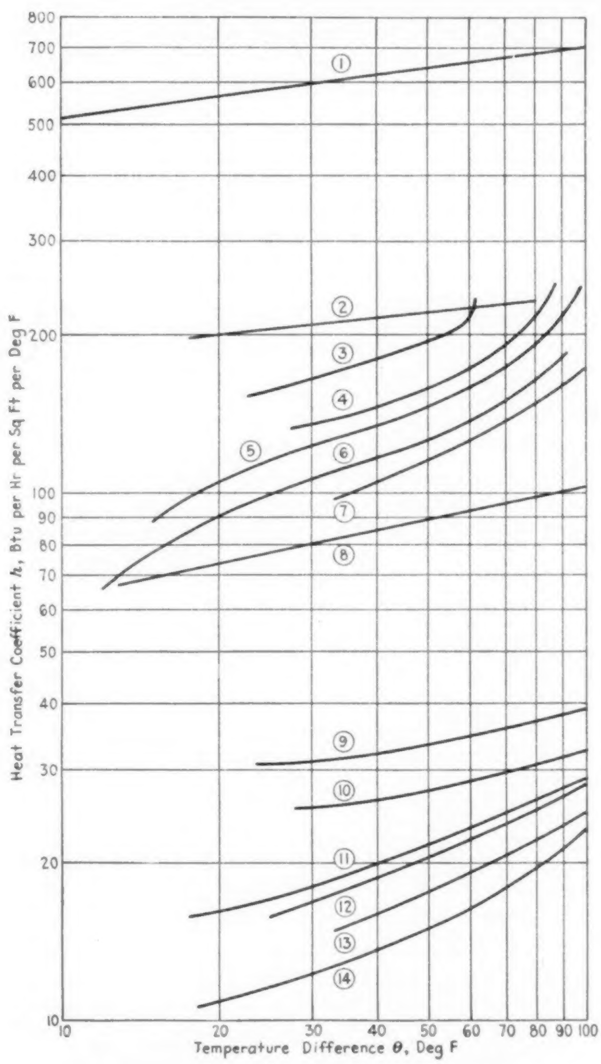


FIG. 8 FREE-CONVECTION DATA FOR VARIOUS LIQUIDS

(1) Nelson, water, 77 F, wire
(2) Nelson, alcohol, 68 F, wire
(3) Montsinger, water, 151 F, block
(4) Montsinger, water, 122 F, block
(5) Ackermann, water, 107 F, cylinder
(6) Ackermann, water, 86 F, cylinder
(7) Montsinger, water, 77 F, block
(8) Nelson, castor oil, 64 F, wire
(9) Montsinger, 10-C oil, 158 F, block
(10) Montsinger, 10-C oil, 122 F, block
(11) Metrovick, oil, 158 F, plane
(12) Montsinger, 10-C oil, 77 F, block
(13) Montsinger, 21-SW oil, 77 F, block
(14) Metrovick, oil, 68 F, plane.

V. M. Montsinger, of the Transformer Engineering Department, General Electric Co., has kindly given the author the results of some tests made for him by S. L. Milner on free convection in water and transformer oils, together with some similar data communicated by the Research Department of the Metropolitan-Vickers Electrical Co., Ltd.

Montsinger's data were obtained for a copper block, about 11 in. long, $1/2$ in. thick and $2^1/_2$ in. high, immersed in water

[16] E. Griffiths and C. Jakeman. *Engineering*, vol. 123 (1927), p. 1.
[17] C. Eberle. *Zeit. V.D.I.*, vol. 52 (1908), p. 481.
[18] F. C. Houghten and C. Gutberlet. *Heat. Piping and Air Cond.*, vol. 4, Jan. 1932, p. 47.
[19] W. J. King. *Refrigerating Engineering*, vol. 19 (1930), p. 163.
[20] W. Mull and H. Reiher. "Der Wärmeschutz von Luftschichten." Beihefte zum *Gesundheits-Ingenieur*, Reihe 1, Heft 28; R. Oldenbourg, Munich, 1930.
[21] P. Nicholls. *Jl. A.S.H.V.E.*, vol. 27 (1921), p. 783.
[22] F. B. Rowley and A. B. Algren. *Jl. A.S.H.V.E.*, vol. 35 (1929), p. 17.
[23] L. W. Schad. *Heat. Piping and Air Cond.*, vol. 2 (1930), p. 957.
[24] E. R. Queer. *Heat. Piping and Air Cond.*, vol. 3 (1931), p. 960.
[25] J. L. Gregg. "Properties of Metal Foil as an Insulating Material;" presented at the A.S.R.E. Convention, Cleveland, Jan. 26, 1932.
[26] W. Beckmann. *Forschung*, vol. 2 (1931), p. 165.
[27] R. A. Nelson. *Phys. Rev.*, vol. 23 (1924), p. 94.
[28] A. P. Colburn and O. A. Hougen. "Studies in Heat Transmission," Univ. of Wisconsin Eng. Exper. Sta. Series No. 70, 1930; also: *Ind. Eng. Chem.*, vol. 22 (1930), p. 522.
[29] G. Ackermann. *Forschung*, vol. 3 (1932), no. 1, p. 42.

and two grades of oil, designated as 10-C and 21-SW transformer oils. The viscosity (μ), in centipoises, of the two oils varied with the fahrenheit temperatures as follows:

Deg F	50	86	122	158	194
μ (10-C)	25	10	5.5	3.5	2.2
μ (21-SW)	66	22	9.3	6.3	4.2

The Metrovick tests were made with a 10-in. × 4-in. vertical surface immersed in an oil which had about the same viscosity characteristics as given above for the 21-SW oil.

The results of these tests, together with some of the data for other liquids, are given in Fig. 8.

Since the value of the modulus a is about a thousand times as large for liquids as for air, and since the slope of the curve of Fig. 4 increases with the value of $aL^3\theta$, it is to be expected that the size of the body should not affect the convection in liquids as soon as in air. This is borne out by the experimental data, which indicate that the coefficient is not appreciably affected by the size when L is greater than about 0.15 ft.

Although Colburn's data were obtained for water flowing at low velocities (about 1 in. per sec or less) in a long vertical 3-in. pipe, his results are brought fairly well into line with those of Montsinger and Ackermann for still water by the equation

$$h = 0.165\,(t_w + 30)\,\sqrt{\theta}\ \text{Btu per hr per sq ft per deg F} \quad [16]$$

where t_w is the temperature of the main body of the water, in degrees fahrenheit. Nelson's coefficients (Fig. 8) are considerably higher because the diameter of his wire was only 0.033 cm.

The data on oils, represented by curves 9 to 14 of Fig. 8, are correlated approximately by the formula

$$h = 17\,\frac{\theta^{1/4}}{Z_f^{0.4}} \quad [17]$$

where Z_f is the viscosity of the oil, in centipoises, at the average or film temperature. Since none of the other relevant physical properties vary anything like as much as the viscosity, this formula should apply fairly well to other hydrocarbon oils.

CONVERSION FACTORS

The following factors are given for converting the coefficient h, as given in this paper, to other common units.

h = Btu per hr per sq ft per deg F

Divide h by	7373	to get	Cal per sec per sq cm per deg C
	0.2048		Kg-cal per hr per sq m per deg C
	1763		Watts per sq cm per deg C

The Newer Cutting-Tool Materials

(Continued from page 334)

valves which would make it possible to have a relatively low speed at the moment the tool enters the work, and allow a rapid speeding up immediately afterward. Where different tools must enter the work at different times, as may be the case when one uses a slide tool as well as a cross-rail tool, slowing-down and speeding-up dogs may be used at various points of the stroke. As was mentioned before, whether such an arrangement would be an economic success would depend on a number of conditions. It would be possible to gain considerably where several planers are in one department, and especially so when a large part of the planing to be done consists of flat work, but it would be an economic failure when there is only one planer engaged on a wide variety of work.

Present-day planers have a higher return than cutting speed. In other words, the limits of planer performance lie in the inability of the tool to cut at high speed. This condition is reversed when using tungsten carbide, when the limit of the performance lies in the inability to run the planer at a higher speed. In still other words, using tungsten carbide tools permits cutting with a speed equal to the return speed. The planer should therefore be arranged to cut both ways, as has been done in the past. However, such planers as have been arranged this way have had to return at the cutting speed, whereas now a planer can cut at the return speed. It should be remembered that this cutting in both directions can only be done when roughing. The finish cut must be taken with a single tool, and in one direction only.

As a rule, shapers are not used for production work, and therefore less advantage may be expected from the use of tungsten carbide in such machines. However, there are cases where the new tools would have sufficient advantages over high-speed steel to justify arranging a shaper accordingly. The reciprocating part in such a machine is relatively light, but on the other hand the strokes are always short, and many reversals must be made per minute. It is therefore necessary to diminish this weight still further, and this can be easily done by constructing the ram of some light alloy, facing it, perhaps, with cast-iron or hardened-steel ways.

Finally, there remains a class of machinery which offers no difficult problems as to the machines themselves, but where great difficulties are met in the construction of the tools. Milling machines have a rotating spindle which must be speeded up, and they present a problem identical in this respect with that of the lathe. All that has been said about the lathe spindle and its drive can be applied to the milling machine. As to the tools, the milling cutters, this is a study in itself and is outside the scope of this article.

Erratum

On page 213 of the March issue of MECHANICAL ENGINEERING, for "minimum" in the fifth line under the center heading "Waste-Heat Installations," read "maximum."

MECHANICAL ENGINEERING

Vol. 54 MAY, 1932 No. 5

GEORGE A. STETSON, *Editor*

Pruned Trees Bear Better Fruit

NEWS of contemplated governmental economies at Washington brings gratifying reassurance that the Administration is conscious of the need for the elimination of duplication and waste. With Government bureaus there is always the danger of overdevelopment, and unexpected growth in activities and expenses. A periodic pruning is an excellent means for assuring taxpayers that only necessary and useful functions are performed.

The Department of Commerce has always appealed to engineers as performing a host of useful services that are profitable to the aspects of national life in which engineers are most vitally interested. If some of the Department's activities have been ill advised they can be abandoned without harm to its most important functions. In the promised economies it is to be hoped that the Department as a whole will suffer no vital losses. The reduced budget should be applied to those phases of the work that have won universal commendation and have proved their worth and practicability. The country and the Department can afford to do without the others. Pruned trees bear better fruit.

Making the Right Start

ONE of the most hopeful experiments made in education during the past few years lies in the field of vocational guidance in precollegiate years. Last summer at the Engineering Camp of Stevens Institute of Technology a group of preparatory-school boys spent some time under the guidance of Dr. Harvey N. Davis and his associates, learning what engineering and engineering colleges are like, and finding out by means of individual and group tests administered by Dr. Walter Van Dyke Bingham and Prof. Johnson O'Connor what natural characteristics and abilities they themselves possessed. Practical engineering work, lectures, and addresses by eminent engineers, and abundant healthful exercise filled each day with interest and profit. The success of the experiment has warranted its repetition this year in the weeks of August 13 to 27.

Both the boy and the profession are well served by sincere and intelligent attempts to arrive at an early decision of the kind of a career for which the boy may be fitted. The engineering profession needs the best men it can get, but it will suffer if men who do not possess the natural characteristics and abilities that are necessary for success are attracted to it by superficial examination or fortuitous circumstances. Such guidance as the Stevens experiment provides under intelligent control should eliminate much waste, disappointment, and discouragement, and prove a boon to boys, their parents, the colleges, and the profession.

Back to Fundamentals

IF WE ARE to apply the methods of scientific research to social problems, as suggested by Mr. Hirshfeld in his article, "Whose Fault?" that appeared in the March issue of MECHANICAL ENGINEERING, we must get back to fundamental definitions and values. Consequently engineers will hail with enthusiasm the spirit that prompts the Social Science Research Council in providing a fund of $25,000 with which Dr. Charles A. Beard is to attempt a determination of "national interest."

The national interest is at the basis of all of our schemes for the improvement of social well-being. The general phrase has special connotations that differ with those who employ it and its synonyms. Until we can agree within reasonable limits as to what factors of life are of national interest, we cannot expect to devise a national program that will represent a real advance in the progress of our civilization. It is likely that some will disagree with Dr. Beard in what he reports as being of national interest. But Dr. Beard's reputation is sufficient to guarantee a sincere and intelligent study, and his report should provide a much-needed basis from which to orient national programs and on which to establish national ideals.

Pig Iron at Magnetogorsk

"MAGNETOGORSK is producing pig iron." According to the New York *Times*, it is with these words that William A. Haven, Vice-President of Arthur G. McKee & Co., summed up his final report to the Soviet Government, dealing with the contract for the construction of the Magnetogorsk plant. The production comes from blast furnace No. 1, while furnace No. 2 is in the final stage of completion. The capacity of the furnaces is 1000 tons per day, but No. 1 is working at half-capacity only. There are two remarkable things about it. The first is that a plant on a scheme as ambitious as that of Magnetogorsk could have been completed at all in a country as backward economically and technically as Soviet Russia, and at a time of world-wide depression. The second is that while the furnaces have been built by American engineers, the present operators are Russians. Unquestionably there will be trouble at first, and this is expected. The fact remains, however, that the furnaces are being operated.

The metal from the Magnetogorsk plant can be used only for domestic furnaces—in the first place because there is a sufficient domestic demand to consume all that the plant may make, and in the second because the plant

has been built so far from any foreign frontier as to make the transportation of the metal abroad, except possibly to Manchuria, prohibitive. The steel will, however, help Russia put through its program of industrialization, and will be vitally necessary in Russia's effort to improve its inadequate system of railroad transportation.

Dispossessing Three Electrons

AN EDITORIAL in *Power Plant Engineering* of December 1, 1931, in discussing the modern vacuum tube, calls attention to the fact that while lead has eighty-two electrons, gold has seventy-nine. If, therefore, we should succeed in knocking three electrons out of lead we might have gold, so that eventually a supply of gold would be a matter of vacuum tubes, high voltages, and kilowatt-hours. In this event what would happen to the monetary system of our capitalistic society?

Gold has become the foundation of our monetary system and the preeminent underlying form of exchange because it is sufficiently abundant to serve the requirements of our economic system without being too plentiful, as is, for example, silver. If some one were to discover a field of gold comparable, for example, to that of iron in the Mesabi district, gold would cease to be the basic monetary metal and would become available for numerous industrial uses where its properties would be valuable. What, then, would happen to our monetary system?

The dollar today is valuable for two reasons. In the first place, it is the only method by which taxes and custom dues can be paid to the Government (except in some cases where gold bullion is accepted). By law the dollar is also a legal means for paying private debts. (This is so, at least, where the proper dollar is used, Federal Reserve notes not always being legal tender.) Today the dollar is also accepted because of the gold deposit back of it. If the gold backing of the dollar became valueless because of a newly discovered art of transmuting metals, then the dollar would be useful only as a means of paying taxes and custom dues. As the amount of money required for this purpose is, however, small, the value of the dollar would fall tremendously, and yet a capitalistic society cannot continue unless it has a stable means of exchange, such as good money. What, then, is to be done?

One solution of the problem would lie in the assumption of the ownership of public utilities by the Government. Suppose that the Government takes over the railroads, gas and electric plants, water supplies, telegraphs, and telephones. With the exception of the railroads, all of these are of a monopolistic character already (or practically so), and all, including the railroads, are under the strict control of official regulating bodies, state and federal. Suppose now that the Government, having taken them all over, should refuse to accept in payment of its services anything except the currency that it has issued. In that case every buyer of a ticket to travel by railroad, every shipper of freight by railroad, every user of the telephone or telegraph, and every consumer of water, gas, and electricity would have to have dollars which represent nothing but means to pay the Government for essential services. In view of the fact, however, that these services affect every one doing business in the country or merely living in it, such a huge volume of dollars would be required that naturally a value for them would be established. Moreover, the amount of dollars in circulation would be automatically adjusted to the volume of business, with the result that while no material foundation for these dollars would be provided, their value need not fluctuate any more than it does in the world today, so long as the Government does not abuse the privilege of issue; and for that matter, as has been shown, for example by Bagehot, no monetary system can remain stable in the face of abuse of issue by the central government or bank.

It would appear, therefore, that while demonetization of gold for any reason whatsoever would unquestionably provoke a vast and profound disturbance in our whole economic organization and would lead to its complete readjustment, it need not, as some people are inclined to think, necessarily endanger our capitalistic structure.

The Patent Office

SCANT notice was given in the press of the country to the moving of the Patent Office to its enlarged quarters in the new Department of Commerce Building in Washington. Timed to coincide with the 142nd anniversary of the founding of this important Government bureau, the event should not be allowed to pass without comment.

When one considers the times in which the framers of the Constitution lived and the character of contemporary conditions and institutions, one is amazed at the foresight with which Section 8 of Article 1 of that historic document was phrased:

> Congress shall have power to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their writings and discoveries.

In 1790 the industrial era was just dawning, and political leaders were still imbued with the philosophy of an agricultural economy. Great inventions and discoveries had been made, of course, and their benefits were becoming more and more apparent, but in the light of the developments of the last 140 years, the surface had scarcely been scratched.

By 1836 the experience gained by operating the Patent Office ripened into the Act of that date, which established the patent-law system practically as it is today. Its administration passed from the Department of State to that of the Interior, and finally to the Department of Commerce. While the patent laws of this country have their critics, the system under which invention and discovery are stimulated finds its major justification in the tremendous technological advances that have accompanied the industrial era. Of this era the system is an inherent and important part.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

STEAM RESEARCH IN EUROPE AND IN AMERICA—II[1]

THE bases of the latest German and American steam tables are discussed next. Each author, in drawing up his tables, started from such properties of steam as seemed to him especially suitable for this purpose, and which were known from extensive series of experiments. The values in question were reproduced by empirical formulas; from these—using some other properties as secondary bases—with the aid of known thermodynamical relations, the remaining properties sought for were calculated. In this, two points were kept in mind: (1) the thermodynamical consistency, which, for instance, is given if an equation of the latent heat leads to $r = 0$ at the critical point; and (2) the consistency with their own or other workers' results of experiments (of course only as far as the author of a table acknowledged their exactness).

As early as 1912 Jakob suggested starting from the values of the specific heat of steam c_p, owing to the fact that their variation with pressure is a good criterion for the deviations from the ideal state of gas. He is of the opinion that he was the first who proceeded in this way to calculate the specific volume v. Mollier and Knoblauch start from the Munich values of the specific heat, whereas Keenan, in the region of lower pressures, bases his tables on the Harvard observations of the Thomson-Joule effect, combined with the Munich values of specific heat, and, at higher pressures, starts from the Massachusetts (M.I.T.) volume measurements. Further, it is general to use the liquid heat values, the saturation pressure, and the latent heat, the first in the widest range having been determined by the Bureau of Standards, and the two latter in Reichsanstalt. Jakob proceeds next to the consideration of the bases of the Mollier, Munich, and Keenan steam tables. Mollier's equations are not quite consistent with Callendar's theory, retaining, however, the form of Callendar's equations. Mollier used them up to the critical region, excluding a small field near the saturation limit. He is now occupied with a new edition of his tables, taking into consideration the recent experimental work.

As regards the Munich steam tables, Dr. Hausen, who drew up the equations for the new edition, was kind enough to send to Professor Jakob for his lectures his calculations which have been since published in the September, 1931, issue of *Forschung auf dem Gebiete des Ingenieurwesens*, p. 319. The equations for $c_p - c_{p0}$ and v, though only based on experimental values up to 120 atm, give correct values above 200 atm, as shown by Koch's exeriments about to be published. Only near saturation are the c_p values beyond 135 atm too high, and the v and i values too small. Therefore in this region Hausen uses the Reichsanstalt values of latent heat and saturation pressure and the volumes observed by the Massachusetts Institute of Technology. The only criticism as to Keenan's tables is that his paper does not show what constant-pressure line is used as a basis for the calculation of ψ.

Having dealt with the fundamentals of the British, German, and American steam tables, Jakob passes on to the thermodynamical checking of values, first treating the determination of volumes from heat contents, and afterward the converse. To begin with, he refers to the values of latent heat r, directly observed in the Bureau of Standards and the Reichsanstalt, the differences up to 270 C never being as much as 0.2 per cent.

Table IX in the original text gives the latent heat r and specific volume v''. One column gives values r_J of the latent heat observed directly by Fritz and Jakob up to 310 C (101 kg per sq cm, 1400 lb per sq in.) and in the succeeding column values r_K, which were calculated by subtracting the liquid heat observed by Osborne, Stimson, and Fiock from the total heat of dry steam according to Keenan's tables. The agreement (within 0.1 per cent) is excellent. The values of the specific

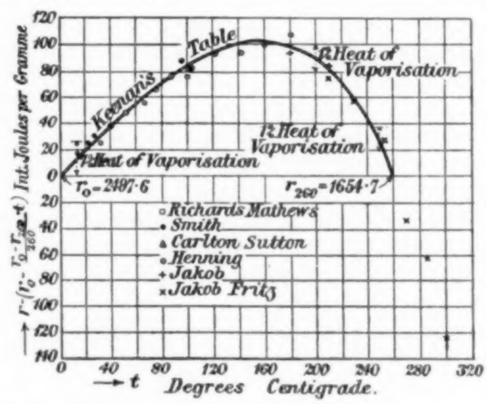


FIG. 2 HEAT OF VAPORIZATION ACCORDING TO VARIOUS EXPERIMENTS

volume (v''_J) have been calculated from Jakob's latent-heat values by means of the Clausius-Clapeyron formula and compared with those (v''_K) in another column, calculated by Keenan, partly from the Thomson-Joule effect values and partly extrapolated from the volume measurements of Keyes and Smith. Up to 240 C they are nearly identical, and beyond that temperature higher (by 1 per cent at 300 C).

A set of isothermals of steam are given to show the values of the volume of superheated steam. At 100 kg per sq cm the order of magnitude of the differences is about 2 per cent.

In the thermodynamical determination of heat contents, Jakob starts with the liquid heat of saturated water. A curve given in the original text shows the liquid heat according to the recent measurements of Osborne, while a prolongation thereof is based on values calculated by Jakob by subtracting the values of latent heat r observed by himself, from the total heat i'', according to Keenan's tables. His curve fits closely to that of the American, extending to 270 C. For comparison the values given by Callendar's theoretical equation are also recorded and this latter curve in the whole region of Jakob's experiments (up to 310 C) agrees remarkably well with his values. Above 310 C the difference between

[1] Part I appeared in the April issue, on pages 282–285.

Callendar's and Jakob's points amounts only to 0.3 per cent.

From the recent measurements of the specific volume published by Trautz and Steyer and by Keyes and Smith, one can calculate the total heat i, and from this the differential Thomson-Joule effect α, the specific heat c_p, and the entropy s of water, by means of thermodynamic formulas which Jakob gives. From an i, p-diagram containing Keenan's isothermals for water, Jakob deduces that the total heat of water below 260 C increases with the pressure, and beyond 260 C decreases. This signifies that 260 C is the inversion temperature, at which the Thomson-Joule effect passes zero. On the other hand, according to Trautz and Steyer, the inversion temperatures are 245 C at 50 kg per sq cm, and about 268 C at 300 kg per sq cm, and change by a linear law within these limits.

Jakob discusses next the calculation of the latent heat, and points to the work of Osborne, Stimson, Fiock, and Keenan, particularly the latter's diagram, Fig. 2, in which one starts from a chord in the r-curve in an r, t diagram and records the difference between r and this chord. This shows an excellent agreement between Keenan's and Jakob's values. In this region a difference of one per cent would amount to almost the height of one square.

As regards the energy of superheat, attention is called to the recent recalculation of older measurements by Henning and Justi, who give, however, only relative values, i.e., the relation of the specific heat of steam to that of air or nitrogen. The greatest deviations from the values calculated according to the quantum theory amount to about $^3/_4$ to $1^1/_2$ per cent, and only at 820 C is there a discrepancy of 2.3 per cent.

The newest and just published Munich c_p-values for 120 kg, 160 kg, and 200 kg per sq cm are given in a set of curves accompanying the original text. A further diagram shows the increase of the total heat at the constant pressure of 240 kg per sq cm observed by Koch, using a step-by-step method. Dr. Koch claims to have freed his water from air by a special arrangement, so that his curve can be compared with that of Professor Callendar for pure steam. Koch's observations do not, however, agree with Callendar's, but confirm the objection of Davis and Keenan to Callendar's theory of the critical region. Dr. Jakob next deals briefly with the sum of liquid heat, latent heat, and superheat.

INTERNATIONAL COOPERATION

After this consideration of the various factors Dr. Jakob proceeds to survey the different experimental bases as a whole. Referring to Fig. 3,

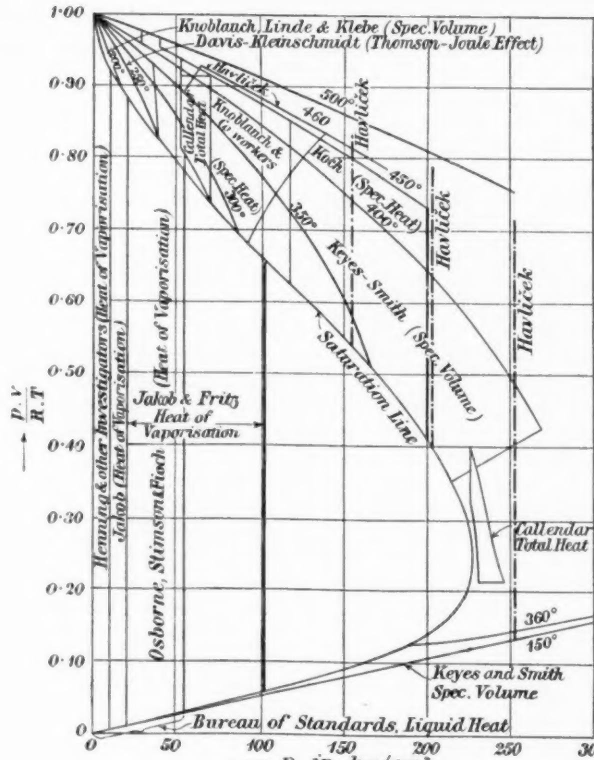


FIG. 3 STEAM RESEARCH IN THE FIELD $\frac{pv}{RT}/p$

TABLE 1 SATURATED STEAM

—	Specific Volume.							Total Heat.						
Pressure, $\frac{\text{Kg}}{\text{cm.}^2}$	50			150		250		50			150		250	
Temperature, deg. C. ..	300	400	500	400	500	400	500	300	400	500	400	500	400	500
Tolerances according to skeleton tables (per cent.)	±0·9	±0·5	±0·6	±3·1	±1·9	±0·8	±2·2	±0·4	±0·3	±0·3	±0·4	±0·3	±0·6	±0·7
Knoblauch, 1923 ..	0·0	−3·4	—	—	—	—	—	+0·3	0·0	—	—	—	—	—
Mollier, 1925	+0·8	+1·3	+1·3	+3·8	+3·4	−3·3	+4·7	−0·1	−0·0	−0·4	−0·6	−0·3	−2·8	−0·4
Callendar, 1929	+0·8	+0·7	+0·8	+3·8	+2·9	+16·1	+2·4	+0·3	+0·1	−0·2	+0·2	−0·2	−3·3	−0·2
Keenan, 1930	−0·5	−0·4	−0·5	+0·1	−1·4	−0·6	−2·8	−0·1	−0·1	+0·1	−0·3	+0·6	+0·4	+1·4

TABLE 2 SUPERHEATED STEAM

—	Saturation Pressure.			Specific Volume.			Total Heat.		
Temperature, deg. C.	150	250	350	150	250	350	150	250	350
Tolerances, according to skeleton tables (per cent.)	± 0·1	± 0·2	± 0·1	± 0·3	± 0·8	± 2·3	± 0·2	± 0·6	± 1·3
Knoblauch, 1923	0·0	− 0·1	—	+ 0·1	− 0·6	—	+ 0·0	− 0·4	—
Mollier, 1925	0·0	− 0·1	− 0·1	+ 0·3	− 0·4	+ 1·0	+ 0·2	− 0·4	− 2·3
Callendar, 1929	—	+ 0·7	− 0·1	—	+ 0·2	+ 3·1	—	+ 0·7	+ 0·9
Keenan, 1930	− 0·0	− 0·2	+ 0·1	+ 0·1	− 0·6	+ 0·1	− 0·1	− 0·1	− 0·1

with pv/RT as ordinate, and the pressure p, for instance, as abscissa, for an ideal gas, all isothermals would fall together into a horizontal line at unit distance from the horizontal axis, $pv = RT$ being the law of ideal gases. For an actual gas, on the contrary, we obtain lower points, the distance of the horizontal line giving the fraction by which, at the temperature in question, the volume is smaller than that of an ideal gas of the same pressure and temperature. It will be seen from the figure, referring to water and steam, that the saturation line of steam begins at zero pressure with the ordinate 1 and sinks to about 0.25 at the critical pressure, which signifies that there the volume is only a quarter of the amount which an ideal gas would have at 225 kg per sq cm and 374 C. Further, it will be seen that the isothermal of 500 C, even at 250 atm, shows a deviation of only 24 per cent from the ideal volume, but that water (the lower branch of the saturation line) is very far from the ideal gas state, namely, by 80 to 100 per cent.

In this diagram only first-class experiments are recorded, and only those which have been published in detail. In the region from 120 to 200 atm Koch's recent tests are recorded, although not yet published. This is followed by a long and interesting discussion of the International Steam Tables Conference, particularly of the chief difficulties which arose dealing with the question of units and the procedure for accepting or rejecting the individual results of research. The former covers the subject of the standard kilocalorie and the standard kilowatt-hour, and the methods successfully adopted to satisfy everybody.

Jakob illustrates in two tables how the steam tables of the different countries agree with the so-called skeleton tables adopted by the International Conferences. In Table 1, he records for different states the tolerances of the skeleton tables as a percentage (first line), and in the following lines the deviations of the different national tables from the assumed values of the international skeleton table. If the latter deviation exceeds the tolerance, the deviation is underlined. In this table, the values for saturated steam are shown. It will be seen that only the newest table, that of Keenan, of 1930, remains always inside the tolerance; the Knoblauch tables extend only to 60 atm. A new edition is on the press.

Table 2 refers to superheated steam at the highest temperatures and pressures. In this case, some of the values in Keenan's table also fall slightly outside of the tolerances, the other tables showing greater differences, one point of Callendar's table falling very far out. It may be mentioned that the new diagram of Callendar, published in 1930, differs in some respects from his values of 1929, which are used in the table.

SPECIAL THERMAL PROPERTIES AND PROCESSES OF WATER AND STEAM (DYNAMICAL PROPERTIES)

The concluding lecture dealt with the special thermal properties and processes of water and steam, particularly those which have been but little investigated up to the present time. These properties are connected closely with the thermodynamical properties previously treated, but their special significance consists in the fact that they are decisive in processes which in a wider sense one may call "dynamical," embracing under this name, hydrodynamical motion, heat transfer, and changes of state.

The first of these considered is viscosity as a decisive factor in hydrodynamical motion. The viscosity of water at 20 C is well known, but with steam at high pressures, combined with high temperatures, absolutely no experimental work has been done. The unit of viscosity is the poise, and the viscosity of water at 20 C is almost exactly 0.01 P = 1 centipoise. The fraction η/ρ in the equation of the Reynolds criterion is called the kinematical viscosity, and Jakob in a paper in 1928 suggested calling the viscosity η the dynamical viscosity, proposing the name "Stokes" for the unit of the kinematical viscosity, because Stokes in England was the first who used this term in his theories. For superheated steam there exist measurements up to and beyond 400 C and up to 10 kg per sq cm.

Speyerer in 1925 measured the viscosity of steam in the range of 100 to 350 C at 1 to 10 atm, but in high-pressure work, values for the viscosity of hot water, and especially of superheated steam, are required at much higher pressures. At present the practice is to extrapolate the latter values up to 10 times this pressure, although Speyerer's values are really not suitable for such extrapolation. Dr. Jakob in cooperation with Engr. Fritz is now carrying out experiments in the Reichsanstalt for steam embracing the region up to 100 atm and 400 C, using the method of the oscillating disk.

The next subject considered by Dr. Jakob was heat conductivity as a decisive factor in heat transfer. This part of the lecture is very interesting, but cannot be abstracted because of lack of space. The same applies to his observations on the heat radiation of superheated steam. Dr. Jakob gives a table of absorption bands for steam, but points out that it is not yet exactly known—and above 1000 C is entirely unknown—how the position, the width, and the maximum absorption of these bands change with the temperature. It is proposed to carry out experiments regarding this question.

In the preceding parts of his lectures Jakob considered such properties of water and steam as are essential for hydrodynamic motion and heat transfer. He now passes on to thermal processes in which these properties play an important part, but restricts his attention to a selection of investigations concerning the most simple cases suitable for physical treatment. Taking up the subject of heat transmission through water or superheated steam, Dr Jakob states that in Germany the coefficient of heat transfer was formerly called the "outer heat conductivity," and was considered as a simple property of the fluid in question or even as a constant value. Actually it is a complicated function of a large number of variables, in addition to which radiation is superimposed over the convection heat, and only the application of the theory of similarity to the problem of heat transfer has made it possible to simplify the matter. Credit for introducing the theory of dimensions into this branch of science and for proceeding farthest with it is given by Dr. Jakob to Professor Nusselt. Dr. Jakob gives several of Nusselt's equations, together with an empirical formula for the coefficient of heat transfer by Schack, which is said to reproduce equally well, or equally badly, the most important experiments with water published up to 1929, its accuracy sufficing for rough calculations.

A summary of the available experiments gives the following limiting values for the coefficient of heat transfer of water: The smallest values (less than 200) exist for forced streamline motion, the values for free motion lying between 200 and 1000, while those for forced eddying motion in pipes lie between 1000 and 8000, the dimensions in each case being kilogram-calories per square meter per hour per degree centigrade.

As regards the heat transfer of superheated steam, special mention is made of the experiments of Poensgen in Munich, who derived an empirical formula which is not quite satisfactory and which does not agree with his own values so well as with Nusselt's equation.

Among the processes involving changes of state, engineers are particularly interested in evaporation and condensation, and Jakob says that it is very strange that so little is known about

evaporation, which is the fundamental process of the whole of steam practice and steam research. His discussion of this, and particularly of the formation of vapor bubbles in absolutely pure liquids, is most interesting, but cannot be abstracted because of lack of space. The Bošnjaković theory of evaporation is referred to. From Jakob's unpublished measurements carried out with a special apparatus which he designed, he quotes the following as a preliminary result:

The heating surface has a markedly higher temperature than the water. The curves in Fig. 42 of the original text show that, at the high rates of evaporation (B) of 50 to 100 kg per sq m per hr, corresponding to the evaporation in a modern boiler, the difference in temperatures, Δt, is 8 to 12 C. Up to $B = 50$ kg per sq m per hr, no points are off the curve; at still higher rates of evaporation, the process appears to be somewhat unstable. With rough plates, Δt is smaller, and the process is more stable.

With the exception of the neighborhood of the heating surface, only very small differences of temperature exist in the water and steam. On the contrary, the temperature of the water is always higher by 0.2 to 0.6 C than that of the steam, the smoothness of the surface seeming to influence this difference.

From the mass of water evaporated in unit time, and from the difference of temperatures Δt, one can calculate the coefficient of heat transfer α. The coefficient of heat transfer rises from 1000 to about 4000, and, for rough surfaces, even to 6000, the rate of evaporation B increasing to 90 kg per sq m per hr. This coefficient of heat transfer corresponds to the usual definition, but Dr. Jakob's observations showed that, even at high rates of evaporation, the water does not evaporate uniformly, but only at a few points of the heating surface. From these points, columns of steam seem to rise, but actually these columns consist of many single bubbles following rapidly one after another, as was observed photographically. The places where the steam originates can be seen after the test as small, slightly colored spots on the surface.

Undercooling of steam in condensation, usually called supersaturation, is a process corresponding to the superheating of water in evaporation. By what mechanism condensation takes place in supersaturated steam free from extraneous particles is not yet known, but several investigations of the subject are referred to by Dr. Jakob. The utmost limit to which supersaturation can be carried is called the Wilson line. Powell recalculated its course and gave certain figures which are about half the amounts obtained from Stodola's experiments. Generally, it seems that the energy losses in nozzles and steam turbines caused by supersaturation have been overestimated.

Heat transfer in condensing dry or superheated steam is considered in the light of German and American investigations, with special mention of Nusselt's theory of heat transfer in steam condensing normally without supersaturation. Jakob's experiments in the Reichsanstalt have confirmed Nusselt's theory qualitatively, whereas quantitatively considerable differences have been found, the figures being given in the original text. The following observation with superheated steam was made: If the superheated steam always entered with the same temperature and velocity into the test pipe, which was cooled outside by water, the steam temperature in the axis at the end of the test length increased, if the wall temperature was reduced by more intense cooling. For instance, the temperature of the steam, entering at 325 C, was, near the end of the pipe, 280 C in the axis, the wall temperature being 95 C, but became 315 C (that is, 35 C higher) if the wall temperature of 95 C was lowered by 20 C. This paradoxical behavior could be explained in the following way: the superheated steam is cooled by steam particles which, from the hot center of the fluid, come to the wall, and, after being cooled there, return in a colder state to the interior. Now, if these particles become condensed on the wall, they do not return into the interior of the fluid, and this therefore remains uncooled. Dr. Jakob also succeeded in confirming quantitatively the correctness of this conclusion by measuring, at the same time, the distribution of the temperature and of the velocity over the section of the fluid. He hopes also that the further thermometric and calorimetric investigation of this phenomenon will give new hints regarding the mechanism of the eddying motion of fluids. (*Engineering*, vol. 132, nos. 3420, 3432, 3433, 3436, 3437, 3438, 3439, and 3441, July 31, Oct. 23 and 30, Nov. 20 and 27, Dec. 4, 11, and 25, 1931, pp. 143–144, 518–521, 550–551, 651–653, 684–686, 707–709, 744–746, 800–804, illus., *etA*)

Short Abstracts of the Month

AIR ENGINEERING

Propeller-Type Fans

SUCH fans have been installed at the Hawthorne Works of the Western Electric Co. in connection with the rehabilitation of the main power plant begun in 1927. In these fans, airplane propellers in tandem have been combined to build up stack pressure sufficient for forced-draft work.

The casings of these fans are 42 in. in diameter by 56 in. long and made of steel plate $^3/_{16}$ in. thick, reinforced by $2 \times 2 \times {}^1/_4$-in. angle rings at each end. The motors are of the totally enclosed squirrel-cage induction type, rated at 15 hp, 1720 rpm, having $1^5/_8$-in.-diameter shafts extended 16 in. at each end. On each shaft extension are mounted four 41-in.-diameter cast aluminum propellers. Each motor is supported within the casing by eight pieces of pipe attached by flanges at their outer ends to the casing and connected at their inner ends to two yokes encircling the motor. Conduit for electric connections and pipes for oiling the motor bearings are brought through the fan casing for convenience in servicing.

The fans have been used for one to two years and have given satisfaction. While the air handled carries considerable abrasive dirt, no detrimental effect from this condition has been observed. Among the advantages are mentioned low first cost and installation cost, less space occupied, less weight, and power consumption approximately 25 per cent less. (W. R. Loveless, Mechanical Engineer, Hawthorne Works, Western Electric Company, in *Power Plant Engineering*, vol. 36, no. 6, March 15, 1932, pp. 244–245, 3 figs., *d*)

ENGINEERING MATERIALS (See also Machine Tools: Tungsten Carbide Tips With Tantalum Binder; Motor-Car Engineering: Cast Crankshafts and Camshafts)

Fatigue of Mild Steel

IN NOVEMBER, 1930, the Council of the North-East Coast Institution of Engineers and Shipbuilders appointed a committee to inquire into the meaning of the term "fatigue"

as applied to mild steels of 0.10 to 0.35 per cent carbon content. The committee has made a report on the subject, beginning with a listing of former definitions of fatigue, and including a brief statement of modern research regarding causes of failure under repeated stresses. They point out that it is now definitely known that the crystalline structure of a metal is not altered by the application of statical or repeated stresses. In their opinion there is sufficient evidence to show that at ordinary temperatures the breakdown of metals under repeated stresses is not due to any change in the crystalline structure of the metal.

It may therefore be concluded that the deformation of a metal under stress is confined to the crystals themselves, and that within certain limits of stress the crystals may submit to elastic deformation, and may in fact supply what may be termed the elasticity of the metal. It also follows that a crystal may undergo some permanent deformation without actually "splitting," and still retain some elastic properties. All indications are that in case of overstress, failure takes place first within the crystals themselves.

The subject next considered was whether in repetition fractures there are any circumstances present which may give rise to a considerable increase of the stress caused by an external load.

What are called in America "stress raisers" are here considered, such as scratches and microscopic cracks. This consideration includes the subject of the redistribution of stresses induced by the presence of such cracks.

The characteristics of fracture under repeated stresses are considered next, as well as the relation between limited stresses for repeated applications and other mechanical tests. The committee comes to the conclusion that there is at present misunderstanding as to the meaning of the term "fatigue." In its use by experimenters it is held to include all failures which may arise from repeated stresses, whether these are due to insufficient material or to improper distribution of sufficient material. On the other hand, under the definition by Gough, fatigue is applied to the failures which occur in the crystals themselves, and also to those which arise from a faulty distribution of stresses. In the light of the examination by the present committee, it appears that within uniform ferrous material the crystal does not fail unless the stress on it exceeds certain determinable limits. The initial failure occurs because it is overstressed, and this can be prevented by providing sufficient material and by seeing that it is so disposed as to reduce the stress to permissible limits. When this is done, the particular section of material under the given load should be capable of withstanding a very large number of repetitions of stress.

The initial failure may be due to: (*a*) Either a defect in a crystal itself, or (*b*) too greater a stress arising from (1) insufficient material as a whole, (2) sufficient material as a whole, but improper local distribution, or (3) a lack of uniformity in the material at a particular part.

While the crystal defect and the lack of uniformity arise from manufacture, the insufficiency of material, either locally or as a whole, is within the discretion of the designer and is a matter of stress distribution.

The designer can determine by calculation and by experiment the proper distribution of material to prevent the stress exceeding the permissible limits, and when this is done the manufacturer has to produce the uniform material of specified quality which will give the desired limits of stress.

If, therefore, the term "fatigue" is to have a distinct meaning, that meaning should necessarily apply to the permissible limits of stress which a material will withstand for a large number of repetitions of stress.

It would help both the designer and the manufacturer if the term were not used for any question of distribution of stress, whether this be caused by original insufficiency of material, or whether it arises from an initial crack due to some metallurgical deficiency or inequality.

If, in the case of failure, it can be shown that the material is not uniform in nature, or reliable in character, and does not reach under test in standard machines the specified permissible limits, then the fault is metallurgical. If, on the other hand, the material satisfies all the physical tests, the failure will arise from a faulty stress distribution and experiments should be able to show where the defect occurs.

It is the considered opinion of the Committee that:

(*a*) For the particular material under consideration, i.e., mild steel, of carbon content, say, 0.15 to 0.35 per cent, of uniform nature and manufacture, there exist at ordinary temperatures certain limiting stresses which it can withstand without failure for an indefinitely large number of repetitions when exposed to (1) reversed bending, (2) to reversed torsion, or (3) to reversed direct tension and compression.

(*b*) The values determined for these limiting stresses vary with the type of testing machine used, and with the shape and surface finish of the specimen tested. Steps should be taken to agree on standard forms of machines and on standard test pieces, so that the relation between the several limiting stresses can be determined, as well as the relation of these stresses to other mechanical properties.

(*c*) The term "fatigue" should only be used when, from one of a variety of causes, any of the limiting stresses have been exceeded.

(*d*) With the above sense, the term "fatigue" means that the material has been subjected to long-continued repeated and reversed stresses which have exceeded the limiting values.

(*e*) "Fatigue" with the sense defined may arise where the amount and disposition of the available material are such that the stress either wholly or locally exceeds any of the above limits.

(*f*) The term "fatigue failure" should be used to describe any method of failure which follows when any of the above limiting stresses have been exceeded. (Abstracted through *The Engineer*, vol. 153, no. 3973, Mar. 4, 1932, pp. 255–257, *gA*)

[Attention is called to an editorial in the same issue of *The Engineer*, on p. 263, which questions the part dealing with the stress raisers and points out that while the report speaks of steel as a perfectly uniform and homogeneous material, in practice we cannot yet rely upon finding it so. In regard to the definition, the criticism offered is that it is not possible, even if it were desirable, to define a term like "fatigue," which is applicable in its engineering and metallurgical sense to all metals and alloys in terms of a particular group of steels, such as those selected for discussion by the committee. Another criticism is that the report makes no reference to the immensely important part which it is now known that corrosion and chemical action play in accelerating fatigue and lowering the safe range of stress.—EDITOR.]

FUELS AND FIRING

Leuna Gasoline and Catalytic Pressure Hydrogenation

CATALYTIC pressure hydrogenation of hydrocarbons as well as catalytic high-pressure hydrogenation of nitrogen and carbon dioxide are being used now on a large scale by the I. G. Dye Industries, Ltd., in Germany (I. G. stands for "Joint Interests"). Chemically, the production of hydrocarbon fuels differs materially from other processes of hydrogenation.

The synthesis of ammonia is comparatively simple, inasmuch as only one final product, namely, ammonia can be produced. The hydrogenation of carbon monoxide is a more complicated matter, as a large number of products can be produced and in order to obtain exclusively the product desired, namely, methanol or wood alcohol, one must employ catalyzers of high selectivity. The situation is much more complicated in the catalytic pressure hydrogenation of fuels since one has to start with a highly complex mixture and organize the process so as to obtain another complex mixture possessing certain technological properties.

The mixture of hydrocarbons known as Leuna gasoline is obtained from lignite-coal tars and mineral oils. While the gasoline contains only low-boiling-point hydrocarbons containing from 4 to 10 carbon atoms, the mineral oil, tar, or coal used as raw material consists of larger and more complex molecules, which must be broken up into smaller fragments in order to produce the gasoline. In addition to this the hydrogen content must be increased, since gasoline contains something like 16 parts of hydrogen to 100 parts of carbon, while, for example, coal contains only 6 parts of hydrogen to 100 parts of carbon. The same applies to tars and the higher mineral-oil fractions, to all of which it is necessary to add hydrogen to obtain the gasoline.

Furthermore, the raw material consists not only of hydrocarbons but also contains appreciable amounts of organically combined oxygen, nitrogen, and sulphur; for example, lignites contain up to 20 per cent of oxygen and oils up to 4 per cent of sulphur. All of these substances have to be eliminated so as not to appear in the final product. Gasoline, as we know, may be produced by a simple breaking up of mineral oils by heat, and may also be obtained in this way from tars and, with greater difficulty, from coals. These processes, however, are accompanied by the production of substances poor in hydrogen, cracking residues, and coke, while the final products are vitiated by the presence of oxygen and sulphur compounds.

A practically complete transformation into gasoline is possible only with the introduction of additional hydrogen, and the measure of the amount of hydrogen for the production of gasoline is given by the difference between the available hydrogen in the initial raw materials and in the final products. To this must be added the hydrogen necessary to combine with the oxygen, nitrogen, and sulphur to form water, ammonia, and hydrogen sulphide. For each 100 grams of carbon, gasoline contains about 10 grams of available hydrogen, mineral oil about 14 grams, lignite-oven tar about 12 grams, coke-oven tar about 6 grams, coal from 4 to 5 grams, and methane about 33.6 grams. Hence in order to produce one metric ton of gasoline it is necessary to add the following amounts of hydrogen in cubic meters, all the figures being approximate. From mineral oil, 200; from brown-coal-oven tar, 450; from coke-oven tar, 820; and from coal, from 1100 to 1200. In actual practice the amount of hydrogen used is larger than the above, this being due to the fact that in breaking up the large molecules of the raw materials into the smaller molecules of gasoline, still smaller molecules are produced in the form of gaseous hydrocarbons very rich in hydrogen. This hydrogen, however, is not lost in so far as gasoline manufacture is concerned, but may be regained by treating the gases in the presence of water vapor or oxygen by catalyzers and using them for the manufacture of gasoline. It may be stated that all the hydrogen required for producing gasoline from mineral oil or low-temperature-distillation tar may be obtained from the hydrocarbons originating in the process of hydrogenating the mineral oil or lignite tar, while in the liquefaction of coal about one-third of the hydrogen must be supplied from other sources by any of the usual methods.

In order to produce gasoline from mineral oils, tars, or coals, it is necessary to employ two processes: splitting or cracking of the molecule, and hydrogenation. However, no matter how high the hydrogen pressure may be, hydrogenation is not possible in sufficient quantity unless a suitable catalyzer is present. The problem of finding such a catalyzer was difficult, because, for economic reasons, the preliminary removal of contact "poisons," such, for example, as that done so extensively in the synthesis of ammonia, is impossible.

Indeed, it is quite surprising that it has been possible to discover catalyzers which are not only completely resistant to "poisoning" and therefore can be employed for a long time, but in which these "poisons" act as a useful working component. It is particularly significant in this connection that the best-operating hydrogenation catalyzers accelerate tremendously the splitting of the molecule, which makes it possible to work with large throughputs even at temperatures only slightly above 400 C and a hydrogen pressure of 200 atm. These temperatures, low as they are as compared with cracking temperatures, present several advantages, and, for example, the building up of gaseous hydrocarbons which, as we know, increases with rise in temperature, here takes place to only a very moderate extent. The process is also free from undesirable condensation reactions, such as take place in cracking, with or without pressure, and with or without hydrogen. It should be also mentioned that the course of the reaction and the character of the end products, in addition to temperature and duration of operation, are also powerfully affected by the choice of catalyzers, the partial pressure of the hydrogen and the raw material, and, of course, the character of the raw materials.

In principle, it is possible in a single operation to start, for example, with tars or high-boiling-point mineral oils and produce gasoline. As a matter of fact, however, largely because of the low vapor pressure of the raw materials, there are no technically available processes that will permit doing this. It has been found, nevertheless, that all of these difficulties may be entirely eliminated by the application of two processes. In the first the high-boiling-point initial materials, in a liquid state and in the presence of a catalyzer, are subjected to hydrogenation at a hydrogen pressure of, say, 250 atm; in the second, a splitting of molecules produces an "intermediate oil," with boiling limits of from 180 to 325 C. This "intermediate oil" which has already undergone purification as regards to oxygen, nitrogen, and sulphur compounds, is then subjected to a second treatment in a vapor state ("gas phase") in the presence of highly compressed hydrogen, and is transmuted into gasoline by being passed over a catalyzer.

It is stated further that for this gas-phase process only oils are suitable which have no fractions boiling at temperatures in excess of 325 C, as these fractions rapidly produce irreversible condensation on the catalyzer, destroying its efficiency.

When working with impure raw materials or when it is desired to apply particularly strict operating conditions, it is advisable to go even lower than this temperature limit of 325 C and to work instead with something like 275 C.

The application of catalyzers and the method of working in the gaseous and liquid phases has endowed the process of hydrogenation with great adaptability as regards the materials that can be employed and products obtained. While Leuna gasoline is equal in respect to quality to other gasolines on the market, it is possible by applying more powerful catalyzers and higher temperatures to produce from the same raw mate-

rials gasoline of higher anti-knock value, which can be used in high-compression engines instead of the usual gasoline-benzol mixtures. All the raw materials already mentioned can be transmuted into such low-hydrogen gasolines. Of course, when the same process is used the anti-knocking characteristic depends on the raw material, and, for example, coal and coal derivatives because of their composition and lower hydrogen content are more apt to produce gasolines with a particularly high anti-knock value.

When milder process conditions are employed, the splitting may be considerably delayed, so that substantially only the hydrogenating action remains, which can be used, for example, for the refining of gasolines obtained by low-temperature treatment of lignites, coals, or shale, or by cracking of mineral oils, as well as for the purification of raw benzol. It is of interest to note that in this process losses of material which occur in other refining processes are practically eliminated, and, for example, in the refining of raw benzol the hydrogenation is limited to the impurities only. Another example of how the gaseous phase works under strongly hydrogenating conditions is given by the production of illuminating oil from intermediate oils. In this process the simultaneous splitting of the intermediate oil to gasoline can be done intensively or less so, but it is characteristic that residual intermediate oil, contrary to what happens in the case of cracking or hydrogenation without a catalyzer, is rich in hydrogen.

Essentially the same holds true for the production of lubricating oil in the liquid phase, as here catalytic pressure hydrogenation produces an enrichment in hydrogen, even in the particles characterized by highest molecular structure. The hydrogenation is here of great importance, as with the same composition and size of molecules the lubricating oil gives a temperature-viscosity curve which is the better the higher the hydrogen content of the oil.

The most important application of the liquid phase of catalytic pressure hydrogenation lies in the production of intermediate oils from high-boiling-point oils, be they mineral oils, tars, pitch, or the like. In the liquid phase intermediate oils may also be obtained from solid coal. In doing this the coal is finely ground, has a heavy oil added to it, and is converted into intermediate oil under a high hydrogen pressure and in the presence of a small amount of a suitable catalyzer. The most important difference between this and the process where tars and oils are used lies in the fact that small amounts of solid residue have to be removed continuously from the oven and freed from the oil adhering to them.

With proper catalyzers it has proved possible to convert into liquid products up to and over 95 per cent of coal and 98 per cent of lignite, and with the evolution of but little gas. It is obvious from these figures that the amount of solid residue has to be very small and the removal of the oil from it comparatively easy. It is expected that the development of catalytic pressure hydrogenation by the I. G. Dye Industries, Ltd., will result in increasingly permitting Germany to produce high-grade fuels and many other valuable oils from locally available raw materials. (M. Pier in *Chemiker-Zeitung*, vol. 56, no. 1, Jan. 2, 1932, pp. 2–3, *d*)

Natural-Gas Fuel for Power

IT IS STATED in this article that the consumption of natural gas in steam-electric plants showed a gain of more than 160 per cent in the eleven-year period ending with 1930. This phase of its utilization is well exemplified in southern California, which is served with electricity by the Southern California Edison Company. A few years ago most of the steam-powered generating plants in this territory were considered as stand-by units for the hydroelectric systems, but this position has been reversed. In fact, the Southern California Edison Company has actually abandoned some of its water-power filings, on the creeks and rivers in the High Sierras, which it had been holding for future development.

The present tendency toward steam as against hydroelectric generation is due largely to improvement in steam-plant efficiency through better equipment and methods, but in part at least to the use of the large available supply of natural gas.

There immediately arises the question of the economy of the Boulder or Hoover Dam project on the Colorado River, as more than 9 per cent of the energy to be generated has been allocated to the Southern California Edison Company and this energy will have to be transmitted 250 miles, over the longest electrical transmission line ever constructed. In this project power was a secondary consideration, the first being water for irrigation and domestic use in a territory where the groundwater level has been falling for years. However, the power will have to return a part of the cost, $165,000,000, and so was allocated by the Government to the near-by states, public utilities, and municipalities.

This power will not be available for approximately 5 years, and its cost delivered at Los Angeles will probably be greater than that at which electrical energy can then be produced in southern California with gas fuel. The amount of energy produced will be easily absorbed in the rapidly increasing volume of energy consumption in that territory. In fact, the ultimate development of the Long Beach plant calls for 1,000,000 kw, with its present capacity but 415,000 kw.

The Long Beach plant of the Southern California Edison Company is the largest central steam-electric generating station west of Chicago, and with unit 12, now under construction, its capacity will be increased to 515,000 kw. Natural gas is brought from Kettleman Hills, a distance of 213 miles, through a pipe line of 26 in. diameter which was completed early in November, 1930, and which has capacity for 130,000,000 cu ft in 24 hr. This will take care of the growing demand for some time, as well as of the decreasing supply from the Southern Basin fields, which are being depleted. It was constructed at a cost of $6,500,000 by the Southern Fuel Company, which is owned jointly by the Southern California Gas Company and the Southern California Edison Company interests. The capacity of this line can be increased to 200,000,000 cu ft daily by the installation of extra compressor plants along the line.

This power plant is divided into three sections. The No. 3 plant, with 200,000 kw capacity, is one of the most efficient built anywhere. Steam is generated in six cross-drum-type boilers with water walls, air preheaters, and superheaters, and each is rated at 3400 hp. These boilers are operated at 450 lb steam pressure and 300 deg of superheat.

A problem now confronting steam-boiler engineers is the design of units in which greater heat liberation per cubic foot of furnace volume can be obtained. Tests at the Long Beach plant were conducted at a maximum heat liberation of 27,300 Btu per hr per cu ft of furnace volume. It was the opinion of the engineers in charge that heat-liberation rates as high as 60,000 Btu per cu ft per hr might be satisfactorily maintained in that furnace. These tests continuously showed a higher rate of heat liberation with gas than with oil. The maximum rating now is 400 per cent, and it is expected that the rate of heat liberation will be increased still further in spite of several limiting factors, a problem which is now the subject of a program of research in which the American Gas Association is collaborating. (J. B. Nealey in *Southern Power Journal*, vol. 50, no. 3 March, 1932, pp. 17–19, 3 figs., *d*)

HYDRAULICS

A New Water Turbine

THE present note refers to a British patent specification, and deals with water turbines for either high- or low-head water falls. The invention consists in utilizing stream-lined mains for the purpose of directing the water in such a manner that its propulsive effect is concentrated more especially upon those portions of the rotor blades of greatest diameter, i.e., the outer portions of the blades or those parts farthest from the turbine shaft where the application of the turning moment is most effective.

In this turbine (Fig. 1) there is provided centrally of the

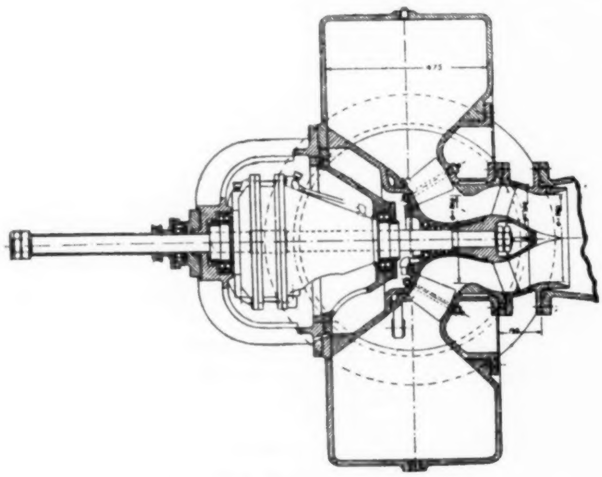


FIG. 1 NEW BRITISH WATER TURBINE

inlet end of the turbine a hub having a hollow-waisted, substantially part-toroidal external surface which reacts with the correspondingly shaped internal surface of the casing in diverting the water from its initial inward direction of flow to a downward direction of flow diverging slightly from the axis of the turbine.

The bladed rotor is disposed adjacent to the hub, and the water after passing between the surface of the hub and the opposed part of the casing or stator, impinges upon the outer part of the blades, where the turning moment is greatest. The angle at which the flow leaves the lower end of the central hub may be called the "angle of impact," which angle can best be arrived at by taking the mean of the varying summer and winter loads or heads during the year with a view to obtaining the best all-round result; or, alternatively, the central hub is interchangeable. Thus, no matter what change of head or load may take place, the "angle of impact" (once decided on) remains constant, and in the most efficient position to deal with the plus and minus variations of the flow.

Further, by guiding the streamlines through the blades in the direction of the blades, cavitation in the space of the inner cross-sectional area below the roots of the blades is reduced to the minimum, which effect is assisted by the directional flow dictated by the lower curve in the stator wall.

In this new turbine the water is guided, not into the narrowest spaces between the blades at their roots, but away from the roots of the blades and toward their outer ends, so that the whole weight and force of the stronger streamlines of the flow are directed against the outer portions of the blades. It results from this that there is no congestion of the flow at the center of the rotor. It does not appear that such a turbine has been built. (*Water and Water Engineering*, vol. 34, no. 399, Jan. 20, 1932, pp. 18–19, 1 fig., *d*)

INTERNAL-COMBUSTION ENGINEERING (See also Motor-Car Engineering: Gas for Road Vehicles)

The Jerk-Pump Injection System for Compression-Ignition Engines

THE jerk type of pump and the differential needle atomizer are extensively used on high-speed light-weight compression-ignition types of engines where a good degree of control over the injection and combustion processes is needed. The author describes the essential features of the jerk pump and the methods of obtaining control, as well as the factors which have to be considered in the design of the pump. One of the important ones is the elasticity of fuel oil, which produces a contraction of volume at various pressures. The control action should not vary the timing of the commencement of injection, and it is preferable that variation in injection timing be obtained by means external to the pump. The three essential conditions affecting pressure variation in the system are stated. For smooth and efficient operation, in most cases the fuel should be injected at a low initial rate, the rate of injection increasing to a maximum at the point where injection ceases. An ideal diagram of the jerk-pump system has been worked out with this in view, and a modified diagram is shown where an almost instantaneous drop in pressure at the end of the injection period is provided. It is pointed out that there is an interval or delay before spill becomes effective, and this may amount to 5 deg (pump) at 1000 rpm. The factors on which this delay depends are enumerated. The whole system of working with this type of pressure variation has certain disadvantages, and in order to obtain the ideal type of pressure variation it is necessary to incorporate some feature which will permit partial unloading of the delivery line when the control action unloads the pump chamber. This can be carried out by several methods, and gives a pressure diagram shown in the original article. It is claimed that in this way the uncontrolled expansion of fuel through the nozzle toward the end of delivery is eliminated. In some of the existing pump designs, notably the Bosch and Benes, the spill action takes place through the overrunning of a small port by a control edge inclined at approximately 30 deg to the direction of motion. Instead an inclined edge working against the slot parallel to it may be provided. A slot gives three times the rate of uncovering of area provided by a round hole for the same plunger velocity, and the substitution of the slot for the round hole considerably reduces the delay before spill becomes effective. The ideal diagram can therefore be approached in practice, and the author eliminates the factors on which possible variations and adjustments to the general form depend.

In order to obtain a sharp cessation to injection, it is necessary to introduce some device which can take advantage of the unloading of the pump-chamber pressure, thereby causing partial unloading of the delivery line. It is also desirable that any device producing this effect should not cause any variation in the timing of the commencement of injection; that is, it should maintain the delivery-line pressure at a constant value under all conditions. This partial unloading is usually obtained by employing a special design of delivery valve. The author cites three methods of obtaining this effect. One is the Bosch type of delivery valve, which is an arrangement that gives a delivery-line pressure varying directly with the maximum fuel pressure, which involves two disadvantages explained in the original article. An alternative arrangement consists of a normal de-

livery valve with a small unloading valve positioned inside it and working in the opposite direction. The unloading valve is controlled by a spring, the strength of which governs the pressure to which the delivery line is unloaded. This arrangement possesses the advantage that if the nozzle hole or holes become blocked, the valve will prevent accumulation of pressure in the delivery line, whereas the Bosch type of delivery valve would accumulate pressure until the system burst. On the other hand, a constant line pressure is not realized with this system. The third method is to completely unload the whole system every cycle, working without a delivery valve in the pump. In this arrangement the differential needle of the atomizer is really the delivery valve.

The subject of pumping efficiency is discussed in detail, including such subjects as variation of speed of operation of the injection system, delivery at varying speed with constant control position as affecting the spilling arrangement, pressure-wave action, and details of design as interesting the manufacturer and user. The most likely fault is failure of delivery due to the presence of air in the system. The differential needle atomizer is also discussed, and the general action of this type of needle valve is described. The system has the disadvantage that as full load and maximum load are approached, the injection period becomes unduly lengthy, with deleterious effect on the efficiency of operation. This is due to the fact that as the quantity of fuel injected per cycle increases beyond a certain value, the nozzle area is insufficient to pass the fuel in the time corresponding to a suitable injection period. Two suggested methods of overcoming this difficulty are as follows: One uses a needle with an extension below the seat ("pintle" type atomizer); the other method involves the variation of the load exerted by the spring on the atomizer needle. The article concludes by a discussion of the testing methods adopted by the author.

The author used the Farnboro electropneumatic indicator, but added to it a device superimposing on the Farnboro records of variation with changes of pressure a diagram representing the rise and fall of the atomizer needle. For determining the injection period where no facilities for operating an indicator exist, an instrument giving a direct reading in pump-shaft degrees was developed. A device for various tests on atomizers has also been developed. In an appendix certain problems have been worked out numerically. (S. W. Nixon in *The Automobile Engineer*, vol. 22, no. 289, Jan., 1932, pp. 31–36, 17 figs., *e*)

MACHINE DESIGN

Planetary Gearing With Two Driving Members

THE author presents a graphical method for the solution of problems of this character. One of the problems is as follows: Given a planetary-gear mechanism in which the initial driver makes 70 rpm and the sun wheel, which is the auxiliary driver, makes 210 rpm, both clockwise, find the direction of turning and the number of revolutions per minute of the follower wheel, assuming that the numbers of teeth in the three wheels are given. The author gives solutions by a graphical method, a geometrical method, and an analytical method.

He also considers the case when the speeds of the sun wheel and train arm are such that the follower is stationary and when the difference in speed of the drivers causes reverse rotation of the follower. The other two problems considered are those of finding the speed of the sun wheel when the train arm and internal wheel are drivers, and finding the speed of the train wheel when the internal wheel and the sun wheel are the drivers. (Franklin DeRonde Furman, Professor of Mechanism and Machine Design, Stevens Institute of Technology, in *Machinery*, vol. 38, no. 5, Jan., 1932, pp. 328–332, 4 figs., *t*)

MACHINE PARTS (See also Motor-Car Engineering: Cast Crankshafts and Camshafts)

Differential Planetary Gearing

DIFFERENTIAL planetary-gear systems offer the designer units that give the maximum speed reduction possible within a specified diameter. Calculation of the numbers of teeth in the gears that make up the train is, however, laborious if usual methods are followed. This article presents a simple method for calculating the number of teeth for any predetermined reduction ratio. It gives the true ratio of the differential planetary-gear systems having numbers of gear teeth previously determined, as well as the true value of the diametral pitch. When the tooth ratios have been calculated, according to the method given in the article, any desired diametral pitch can be substituted. A numerical example is given to illustrate the methods used. (L. F. Michael, Blaw-Knox Co., in *Product Engineering*, vol. 2, no. 11, Nov., 1931, pp. 490–492, 2 figs., *pm*)

A Sleeve-Type Roll-Neck Bearing

A SLEEVE-TYPE roll-neck bearing, fully enclosed and flood-lubricated, intended for general rolling-mill application, has been developed by the Morgan Construction Co., of Worcester, Mass. In contrast to the ordinary open babbitted bearing, lubricated with roll-neck grease and cooled by water, the new bearing, known as the Morgoil bearing, is designed to receive oil from a circulating-filtering system and is said to permit full realization of the benefits of an oil-lubricated bearing. Lubrication can be supplied by a standard mill circulating oil system when such is available.

Roll necks proper are not used as journals, accurately made sleeve journals being provided in the unit construction, and when bearings are changed the entire unit, including the sleeve journal, is removed intact. By this construction bearing surfaces are protected fully, and cannot be injured when changing bearings from one roll to another. Roll necks having a slight taper are used, making the unit bearings readily removable. The coefficient of friction varies from 0.0018 to 0.004, depending upon the viscosity of the oil and the speed of rotation. No water is required as the negligible amount of friction heat generated is carried away by the oil. This low coefficient of friction results in appreciable power saving. (*Steel*, vol. 90, no. 12, March 21, 1932, p. 35, *d*)

MACHINE SHOP

Adapting Machine Tools to New Jobs

THIS article gives examples of machines that have been adapted by simple changes for work differing from that for which they were designed. Thus, the planer-type milling machine was originally purchased for milling the manifold side of cylinder blocks. When the operation was discontinued it was remodeled to adapt it for rough and finish facing the joint faces of cylinder heads in one operation.

For this new operation, it was necessary to bring the two cutter spindles into line with the table travel. The cost of an entirely new spindle head was avoided by the use of two offset columns, which provide for mounting the head so that the cutters are brought in line for taking the roughing and finishing cuts in succession.

A number of multiple-spindle drilling machines have been transformed into tapping machines by the simple addition of a reversing switch on the driving motor. This switch is tripped automatically when the spindle head of the machine is fed down to the desired depth.

Next there is a multiple-spindle drilling machine that was originally equipped with a mechanical feed for the drill head. To meet certain needs the machine has been provided with the standard hydraulic mechanism for feeding the table and work to the drills, and for returning the table at the end of the operation.

Another machine which has received hydraulic equipment was originally a rail drilling machine furnished with a cam feed for moving the table to and from the drills. The hydraulic equipment automatically indexes the table crosswise to bring the first group of six holes into line with the cutters, and does a number of other things. The hydraulic mechanism is operated by a cam at the rear of the machine which is mounted on a worm-gear shaft formerly used to raise and lower the table, and one revolution of the cam produces the full cycle.

A six-spindle honing machine has been rearranged for chamfering the bottom of the cylinder bores, which required, among other things, a redesign of the tools. The operating cycle has been made entirely automatic, with the table actuated through a cam driven by an individual motor. Two machines are attended by one operator, and the total time required for changing the cylinder blocks in both machines is twelve seconds. (Jos. P. Lannen, Tool Supervisor, Graham-Paige Motors Corp., Detroit, Mich., in *Machinery*, vol. 38, no. 5, Jan., 1932, pp. 333–335, 5 figs., *p*)

The Economics of Tooling Determination

At first thought it seems wasteful to suggest that it might be more economical to produce parts at a cost of \$1.20 each for direct labor instead of two cents.

A good job of tooling is generally considered to be that by which the part is produced for the least possible direct labor, while as a matter of fact, this frequently proves to be the most expensive way of producing the part. The figures of the cost department or estimating department, where one is maintained, are generally used in arriving at a conclusion. Such figures are generally made up by throwing all tool costs into a burden account and distributing it uniformly over the direct labor. This procedure may give a very inaccurate picture on an individual part.

There seems to be a tendency for each shop to specialize in one particular class of tooling, and to tool practically everything in that shop according to the accepted standards. This practice disregards entirely the fact that in almost every case there will be found a wide variety in the total production quantities involved.

A much truer picture can be obtained by considering various classes of tooling that might be used for the part under consideration, and figuring comparative costs on the basis of direct labor plus the distributed tool cost which is obtained by dividing the total cost by the quantity which is estimated will be required. This method disregards entirely the other burden items which will not be affected.

The author presents a chart dealing with four "classes." Class A involves the use of \$15 worth of simple tools, and would result in a direct labor cost of \$1.20 per unit.

Class B involves the use of \$500 worth of tools, by the use of which the direct labor cost will be reduced to 30 cents per unit.

Class C involves somewhat more elaborate tooling, costing \$1000, and reduces the direct labor cost to 10 cents per unit.

Class D is estimated for tooling made as fully automatic as possible, will cost \$5000, and reduces the cost for direct labor to the small sum of 2 cents per unit.

It is shown that for quantities of less than 400 it is cheaper to use the very simple tools and spend \$1.20 each for direct labor.

For quantities between 400 and 2400, Class B tooling will represent the smallest overall cost, while Class C tooling will be economical for quantities between 2400 and 50,000. Class D tooling, which gives us the 2-cent direct labor cost, is not economical unless more than 50,000 parts will have to be made. (Edward Hughes, Vice-Pres. in charge of Manufacturing, Copeland Products, Inc., Mt. Clemens, Mich., in an address delivered before the *American Society of Refrigerating Engineers* and the *American Society of Heating and Ventilating Engineers*, Cleveland, Ohio, Jan. 26, 1932, abstracted from publicity release, *gp*)

MACHINE TOOLS

Tungsten Carbide Tips With Tantalum Binder

This material has been evolved by Gregory J. Comstock, Director of Research of the Firth-Stirling Steel Company, McKeesport, Pa.

In cutting steel with tungsten carbide alloy formed with cobalt as a binder, it was found that a chip cavity was developed directly behind the cutting edge of the tool. This crater was ordinarily sufficient to shorten materially the cutting life of the tool, and the condition was particularly noticeable in the machining of soft steel.

It was then found that the substitution of tantalum carbide for tungsten carbide cemented with tantalum-carbon-tungsten cobalt alloy produced a tool which would cut steel without developing the objectionable crater behind the cutting edge of the tool.

This led to the development of a series of alloys in which tantalum only is used as an additive. It is said that the principle on which these alloys have been developed has been to reduce slightly the heat conductivity of the tungsten carbide material as a step in the direction toward lengthening the life of tools. Reference is made in the article to the "insulation-lubrication theory" of producing hard cemented cutting alloys which the author's company is now utilizing. (T. H. Gerken, Pittsburgh Editor of *The Iron Age*, in *The Iron Age*, vol. 129, no. 10, March 10, 1932, pp. 600–601, illust., *d*)

MOTOR-CAR ENGINEERING

Gas for Road Vehicles

In the course of his chairman's address to the shareholders of the Tottenham and District Gas Company recently, Mr. Henry Woodall referred to the use of compressed gas for the propulsion of road vehicles. In Paris, he said, much progress had been made and numbers of cars were running there on compressed gas. The company's engineer, Mr. Smith, had examined the French system and written a full report upon it. That report stated that the vehicles ran very well and that the drivers preferred the compressed gas to gasoline. In view of that report the company had decided to obtain cylinders for experimental purposes, and he hoped that it would soon have gas-driven lorries in operation. He believed that the possibilities of the system were great. If the bulk of the omnibuses in London were run on gas, no less than half a million more

tons of coal would have to be carbonized every year—"a matter of some national importance." Mr. Woodall gave the convenient figure that the gas produced from 1 ton of coal was equal, approximately, to 50 gal of gasoline. (*The Engineer*, vol. 153, no. 3972, Feb. 26, 1932, p. 227, *g*)

Cast Crankshafts and Camshafts

AT LEAST three manufacturers of automobiles and two manufacturers of parts have been engaged in noteworthy development work on cast crankshafts and camshafts. A camshaft of the following analysis was recently run 500 consecutive hours in an automobile engine, developing more than 100 hp with the throttle wide open: Total carbon, 3.15; graphitic carbon, 2.61; combined carbon, 0.54; manganese, 0.48; silicon, 2.34; sulphur, 0.066; phosphorus, 0.11; molybdenum, 2.25; nickel, 1.70; and chrome, 0.08. The only appreciable wear—and it was not great—was on the gear operating the oil-pump shaft.

Cast crankshafts have been put in experimental automobile engines and found to have this merit: While the tensile strength of 70,000 to 80,000 lb is about 10,000 lb below that of a normalized steel forging, the elastic limit is higher than in steel and approximates its own tensile strength, thus giving the cast crankshaft great fatigue value.

In conjunction with babbitt or bronze it is claimed that the cast crankshaft makes an unusually good bearing. Such crankshafts have been made in an electric furnace with cold melt, or in a cupola and electric furnace by the duplex method, or in an air furnace. (*Steel*, vol. 90, no. 12, March 21, 1932, pp. 23–24, *d*)

The Daimler Bus

IN THE latest Daimler double-decker bus, a new poppet-valve engine is installed. Two other improvements are the fluid flywheel and epicyclic-gear box. No detail about the design of the engine is given, except the valve diagram. To avoid the possibility of the pistons, cylinder walls, etc. becoming dry or insufficiently lubricated when the engine is first started up from cold, a "bleed" is drilled in each of the big ends of the connecting rods in such a position that a stream of oil is slung out when the crankshaft is revolving, a part of the oil reaching the cylinder walls and piston skirts. Some details are given about the epicyclic-gear box. (*The Commercial Motor*, vol. 50, no. 1400, Jan. 12, 1932, pp. 784–787, illustrated, *d*)

POWER TRANSMISSION

The Thyratrons

AS THYRATRONS are developed in larger sizes, they will change entirely the methods of power transmission, particularly in cities.

In many of our cities the underground conduits are now overloaded, and yet the demand for power is continually increasing. If power could be transmitted by direct instead of alternating current the capacity of these conduits could be increased between two and three times, and it should not be so very long before we can take care of it with tubes rectifying the alternating current at the transmitting end, transmitting as direct current, and then at the receiving end transforming back to sixty cycles for distribution on the present circuits.

Furthermore, this suggests another possibility not to be expected within the next ten years, if at all, but one which seems to have no insuperable obstacles in the way of its accomplishment. That is, the superpower transmission system of the future. We have about reached the distance limit for economical transmission with alternating current, but it can be shown that with direct current the economic radius can be increased almost ninefold.

There are water powers up in Canada which are too remote from any point where the energy can be used to make their development economical today, but if we could transmit at possibly 400,000 volts direct current, then their development could be justified. So it is a possibility that the superpower system of the future will employ these tubes again at the generating end, rectifying the alternating current, say, to 400,000 volts d.c., and then at the receiving end transforming back to alternating current for stepping the voltage down for distribution.

Also such things are suggested as electric locomotives, operating on a 15,000-volt trolley, with induction motors for the driving motors, supplied with alternating current of variable frequency so as to give the speed control, through thyratron tubes supplied from the 15,000-volt d.c. trolley. (From a lecture entitled, "Adventures in Science," by L. A. Hawkins, Executive Engineer, General Electric Research Laboratory, Schenectady, N. Y., in *Journal of the Western Society of Engineers*, vol. 37, no. 1, Feb., 1932, pp. 20–29 and discussion, pp. 29–30, *g*)

PUMPS

The Varley Rotary Pump

THE series of diagrams in Fig. 2 will serve to demonstrate the action of the pump. The central part *A* and the outer ring *C*, it will be seen, remain stationary while the horseshoe-shaped portion is moved, as shown by the diagrams. The motion is communicated to it by the cranks *D* on the wheels *E*, which are themselves driven by a central gear wheel from the main driving shaft. Referring to the diagrams, Fig. 2, it will be seen that at *a*, suction is taking place in the space between the berms of the horseshoe, while the liquid between

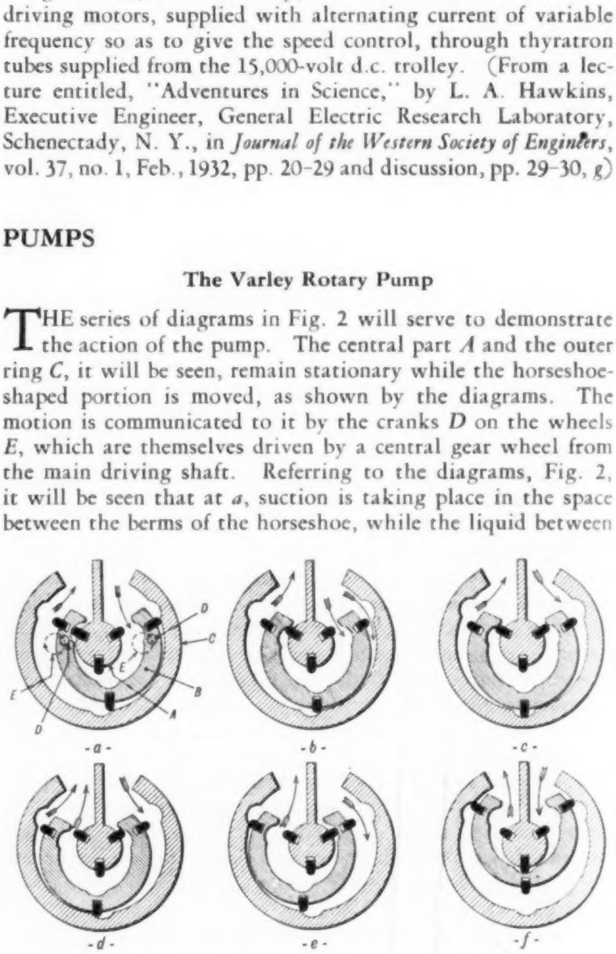


FIG. 2 THE VARLEY ROTARY PUMP

the horseshoe and the outer ring is being forced out of the delivery port. As the cyclic action continues, suction begins to take place outside the horseshoe as well as within its berms, until a state is reached at which suction is taking place outside the horseshoe, while the liquid within the berms is being delivered. Subsequently, the cycle begins again. In this manner a steady flow of liquid is obtained. It will be noticed that contact between the moving and stationary parts only occurs at a few places. The lugs at the points are pressed outward from the slots in which they fit by springs, and restrained from

falling out when contact is not made with another surface by projections specially formed to withhold them. The pump is driven through totally enclosed gearing, which can be varied to suit a wide range of speed of the driving motor. The makers claim that the pump is partially suitable for gasoline-dispensing metering units, fuel-oil lorries, and similar applications. (Part of an article describing the British Industries Fair at Birmingham, England. *The Engineer*, vol. 153, no. 3974, March 11, 1932, pp. 283, *d*)

RAILROAD ENGINEERING

Car for Handling Granular Commodities

SUCH a car under the name of "Dry-Flo" has been developed by the General American Tank Car Corporation. It is intended to be used for such dry materials as cement, lime, flour, sulphur, fertilizer, soda ash, etc.

It has two characteristic features. One is the single outlet at the bottom through which bulk contents of the car are uniformly unloaded at a rate best adapted for subsequent handling by proper conveying equipment.

The other feature is the drag chain conveyors which are drawn from each end toward the center of the car. The lading is pulled along with the chains and dropped from them into the discharge opening. The chains continue upward and back across the top of the car to the ends. Dry commodities tend to pack and arch. An unloading mechanism such as provided here is therefore very essential. It is stated that as one of the results of this development, for example, a large contracting company has decided to use these cars rather than motor trucks for transporting cement from the cement-producing plants to its mixing plants. Another shipper who has been using hydrated lime in his manufacturing processes instead of the cheaper and more efficient quicklime, on account of the danger to workmen with the latter, finds that since lime in a Dry-Flo car does not come in contact with human hands, he can now substitute quicklime with a very impressive saving at the end of the year. The handling of dangerous commodities such as arsenic is an unpleasant and difficult job for manual labor. Substitution of the Dry-Flo car eliminates the hazards to plant employees, besides effecting a considerable saving to the management in dispensing with barreling. (L. A. Belding, Manager, General American Tank Car Corporation, in an address before the *Engineers' Club*, New York, March 23, 1932, *d*)

SPECIAL MACHINERY

Cold-Swaging Forging in Tubing Manufacture

THE new machine is capable of reducing in one pass a steel tube of, say, $2^1/_4$ in. outside diameter with a wall thickness of $^1/_4$ in. to one of $1^1/_4$ in. outside diameter and a wall thickness of 0.09 in. It has been developed for the Pipe and Tube Bending Corporation of America, Newark, N. J., a subsidiary of the Tube Reducing Corporation, by Geo. B. Coe, and has been patented.

A reciprocating crosshead or saddle contains two rolls which perform a combined cold-swaging forging operation on a length of the tube. The tube is pushed along step by step from a tapered mandrel, and reduced to the final diameter.

On the forward or forging stroke, two mating dies fitted into the rolls squeeze the tube, and the metal is made to flow longitudinally under the pressure. At the end of the forward stroke the tube is rotated 60 to 90 deg. and when the saddle makes its backward stroke the dies do a certain amount of kneading of the metal. This operation causes the metal to flow concentrically around the walls of the tube. Just before the beginning of the next forward stroke the tube is pushed into the rolls, say, $^1/_4$ in., and the dies again do their work on the forward stroke.

The heart of the machine is the scheme of rolling. The two rolls are spur-geared together outside the roll necks, and the teeth of the gearing of the lower roll mesh also with the teeth of a rack. When the connecting rods slide the saddle

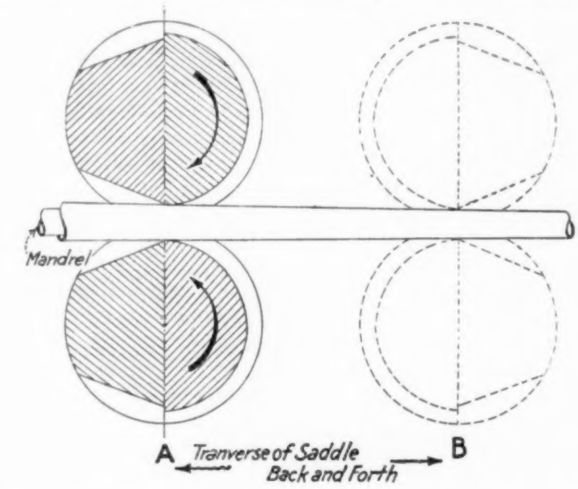


FIG. 3 SWAGING-FORGING DIES IN THE TUBE-REDUCING CORPORATION'S MACHINE

(that is, the housing of the rolls), the rolls are forced to revolve; the lower by mating with the rack and the upper because it is in mesh with the lower. The rolls make a half-revolution each stroke. The half of the rolls which come into contact with the tubing carry the forging dies; the other half of the rolls are semi-cylindrical, except that in the dies themselves relieving is necessary to escape interference at the end of each rocking with the tube extending through the machine.

As the dies roll from *A* to *B*, Fig. 3, the tapered gears squeeze the tube against the tapered mandrel. On the return stroke, the tube being rotated for a portion of a revolution, the dies work out any likely eccentricities in the tapered portion of the tube.

While the machine may at first convey the impression of giving heavy drafting of the metal, the kneading manipulation the metal gets is slight at any one point in view of the number of times pressure is applied. Pressure is mainly transverse across the tube walls and is taken up mostly by the rolls and thus transmitted to their housings. The result is that the thrust pressure is relatively light and the flow of metal is toward the outgoing end. Copious supplies of water keep down the temperature so that the tube as it issues from the machine is barely warm. (*The Iron Age*, vol. 129, no. 11, March 17, 1932, pp. 676–677, 2 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive, *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

OPENINGS IN CYLINDRICAL DRUMS

Rule for Determining the Maximum Size of Opening That Can Be Used in the Shell of a Boiler or Pressure Vessel Without Reinforcement

By D. S. JACOBUS[1]

Much thought has been given by the A.S.M.E. Boiler Code Committee to the question of the largest size of an unreinforced opening that should be used in a cylindrical drum or shell of a boiler or pressure vessel without reinforcement. The problem is a difficult one as a correct solution involves the effect of the redistribution of the stresses in the shell after the most highly strained parts exceed the elastic limit of the material.

The distribution of stresses within the elastic limit around a circular opening, such as a tube hole, is well known, the stresses at the sides of the hole being over twice the average stress as ordinarily computed in determining the strength of a drum. Even should comprehensive experiments be made to show the redistribution of stresses when the elastic limit at some point is exceeded, there would still remain the problem of setting the stress that could be safely used in computing the strength of the drum.

It is well known that the so-called factors of safety used in the formulas for designing boilers and pressure vessels are factors for guidance in design and construction rather than actual factors of safety. It has been pointed out that the ordinary rules for determining the factor of safety of a cylindrical tube sheet, which are based on the average stress in the ligaments between the tube holes, would differ greatly from those for a factor based on the maximum stress existing at the sides of the tube holes, and that the factors of safety now used are far from correct should they be defined as the ratio of the tensile strength of the material to the maximum stress in any part of the structure. The effect of the redistribution of the stresses after load is applied must be considered in any rules bearing on the strength of boilers and pressure vessels, and it is for this reason that the ductility of the material used in shells and other pressure parts is an important element.

Our rules for the construction of boilers and pressure vessels are the outcome of long experience through use in practical service. The factor of safety of 5 employed in the A.S.M.E. Boiler Code for the construction of power boilers and for pressure vessels for stationary service applies to shells pierced with holes and provides a reasonable margin for deterioration through corrosion or like causes. A pressure vessel having a shell which is not pierced with a hole and which contains no other stress raiser in the metal of the shell, such as a groove or

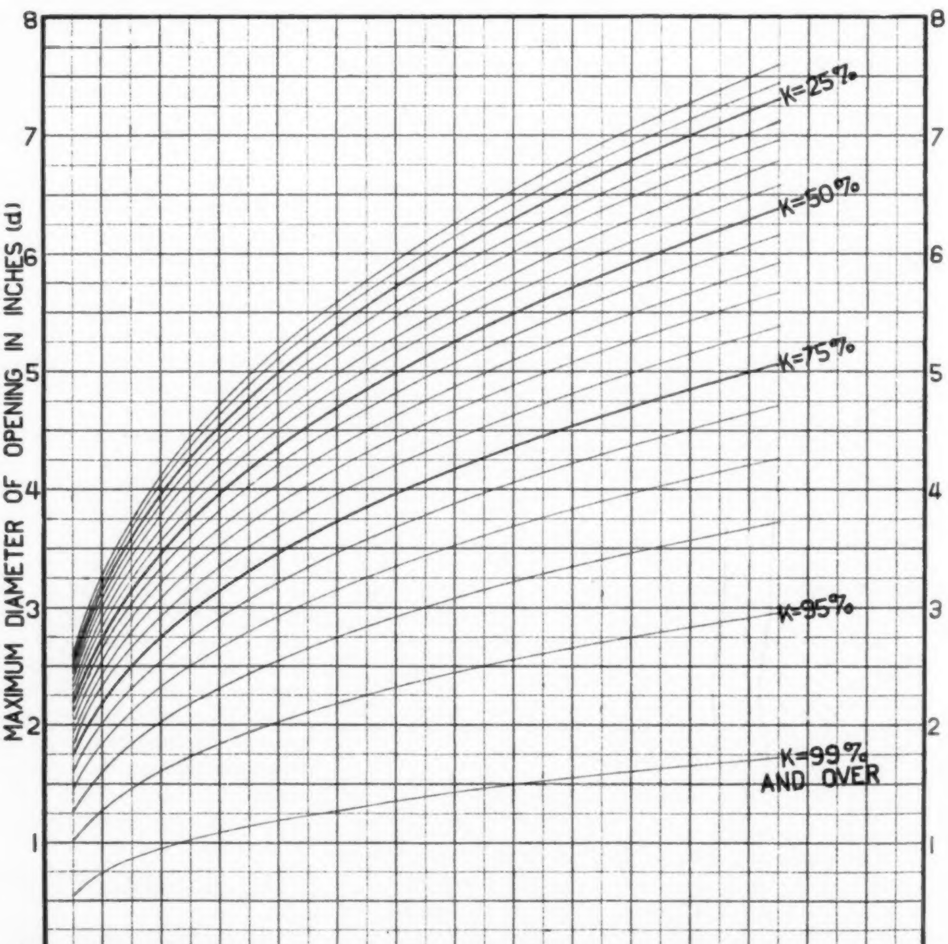


FIG. 1 MAXIMUM DIAMETER OF UNREINFORCED OPENINGS IN SHELLS ($Dt \leq 25$)

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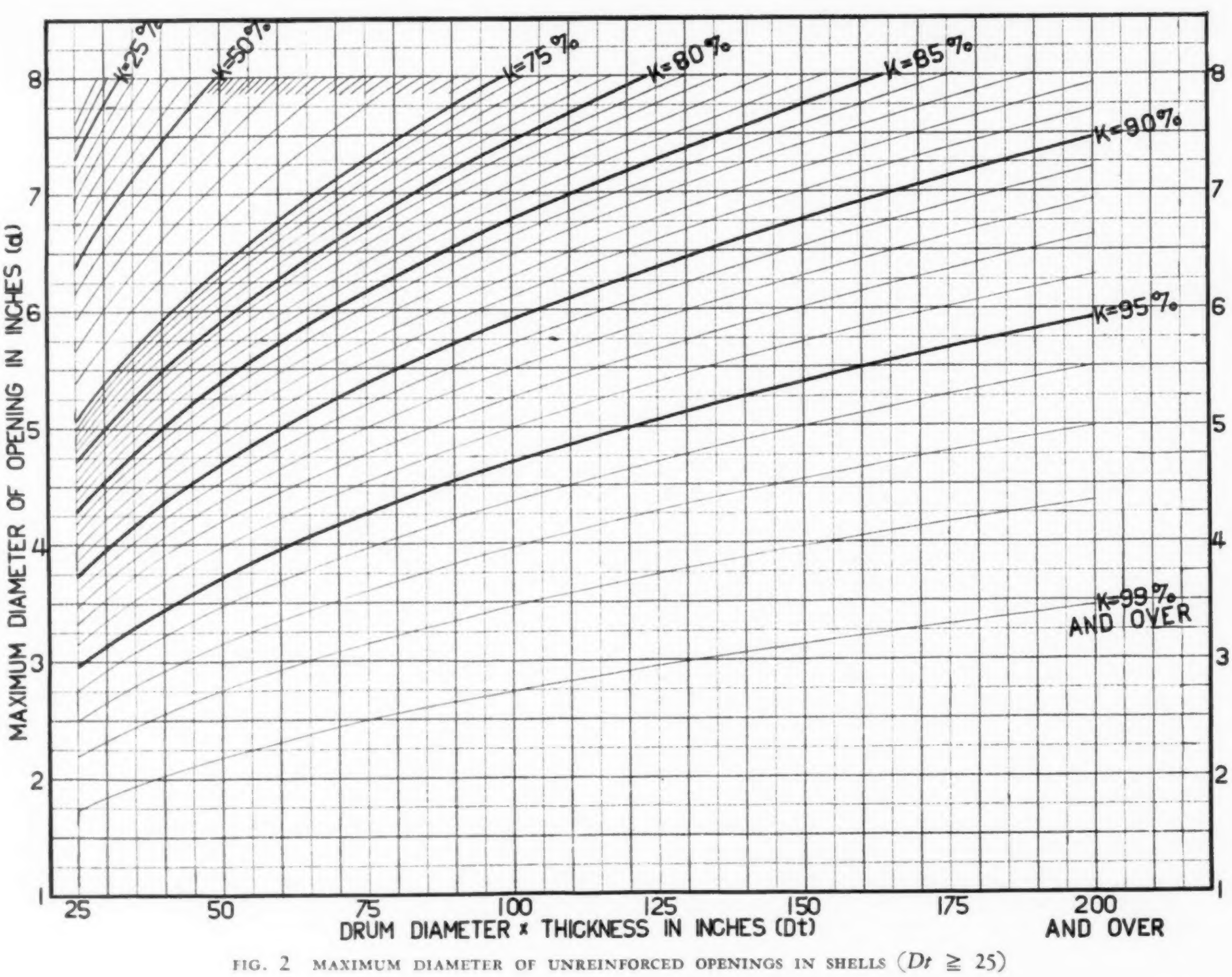

FIG. 2 MAXIMUM DIAMETER OF UNREINFORCED OPENINGS IN SHELLS ($Dt \geq 25$)

deep scratch, could be used with safety at higher pressures than one which contains a stress raiser. Again, the class of service to which a pressure vessel is subjected must be taken into consideration as an intermittent pressure may lead to failure where a constant pressure would not. The effect of corrosion fatigue must also be considered. When it is appreciated how many elements enter the problem, the difficulty of obtaining an exact solution will be apparent. The solution which follows is not an exact one, but has been developed to provide a rule which will give safe results without involving undue hardship. It is based on data secured through the use of certain constructions of which a great number have been used and which have given satisfaction in long-time service. It applies to circular holes in a cylindrical shell when used for tube holes or the like.

The rule is based mainly on the size of unreinforced openings that have been successfully used in long-time service for headers of superheaters and water walls. It applies to cylindrical drums constructed from steel of the quality specified in the A.S.M.E. Boiler Code. It was developed for shells 8 in. or more in diameter in which the shell thickness does not exceed one-fifth the diameter, and in which the largest hole does not exceed six-tenths the diameter of the shell.

If the law of geometric proportions would hold, and a 4-in.-diameter hole in a 12-in. header $^3/_4$ in. thick has given safe and reliable results, it would follow that an unreinforced hole 20 in. in diameter could be placed in a drum 60 in. in diameter having a shell thickness of $3^3/_4$ in., provided the working pressure was the same in both cases. In the rule proposed the openings in the larger drums would be much smaller than sanctioned by the law of geometric proportions, as it is not necessary to provide as large openings as would be determined by this law; and, again, there are other elements, such as the cross-strains which come on connections to larger drums, which make it advisable not to sanction an unreinforced hole of too large a diameter.

The proposed rule is as follows:

$$d = 2.75 \sqrt[3]{Dt(1 - K)}$$

where d = maximum diameter of unreinforced circular opening, in.

t = thickness of shell plate, in.

K = ratio of computed stress in the solid plate to one-fifth of the minimum of the specified range of tensile strength of the steel forming the shell

$= \dfrac{PD}{2St}$

where P = maximum allowable working pressure, lb per sq in.

D = outer diameter of shell, in.

S = one-fifth of the minimum of the specified range of tensile strength of the steel forming the shell, lb per sq in.

TABLE 1 COMPARISON OF DATA SECURED FROM PRACTICE WITH THE PROPOSED RULE

Efficiency, per cent	Drum diameter, in.	Thickness, in.	d, Practice in.	d, Proposed rule, in.
45	36	$^5/_8$	$5^7/_8$	6.36
50	$12^3/_4$	1	$4^{17}/_{32}$	5.10
50	$11^3/_4$	1	$4^1/_{32}$	4.96
50	$9^1/_4$	1	$3^9/_{32}$	4.58
70	42	$^5/_8$	$4^{17}/_{32}$	5.47

A comparison of the data secured from practice with the proposed rule is given in Table 1. The results of the application of the rule are also shown in Figs. 1 and 2. As indicated in these figures, it is proposed to base the maximum diameter of opening to be used without reinforcement for a shell having a higher ligament efficiency than 99 per cent on that for a shell having an efficiency of 99 per cent. This will allow for placing a relatively small hole in a drum computed for an efficiency of 100 per cent. Placing a hole in an otherwise seamless shell would greatly weaken the shell, but it should be remembered that the rule herein proposed is for use in connection with the so-called factor of safety of 5, which applies to drums pierced with holes.

In Fig. 2 the maximum diameter of opening is given as 8 in. with the idea that by so limiting the diameter no hardship will be involved and the rule may be made correspondingly safer.

REVISIONS AND ADDENDA TO THE BOILER CONSTRUCTION CODE

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and approval from any one interested therein. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y., in order that they may be presented to the Committee for consideration.

Note: In identical revisions in paragraphs of power and unfired pressure vessel codes the material appearing within brackets refers only to the text of the paragraph of the Code for Unfired Pressure Vessels.

PAR. P-23. REVISED:

P-23. *Thickness of Steam Piping.* In determining the thickness to be used for pipes at different pressures and temperatures the following formulas are to be used:

For pipes having nominal diameters of 1 in. and over:

$$P = \frac{2S}{D}(t - 0.09)$$

or

$$P = \frac{1.75S}{D}(T - 0.1)$$

where P = working pressure, lb per sq in.
t = minimum thickness of wall of pipe, in.
T = nominal thickness of wall of pipe including mill under tolerance of $12^1/_2$ per cent, in.
D = actual outside diameter of pipe, in.
S = factor to be taken from Table P-5A.

Where the temperature differs from those in the table, the value of S may be determined by interpolation.

For pipes having nominal diameters less than 1 in. the value of the constant between the parentheses in the formulas to be subtracted from the thickness shall be as follows:

Nominal pipe size	$^3/_4$ in.	$^1/_2$ in.	$^3/_8$ in.	$^1/_4$ in.
Constant for first formula	0.08	0.07	0.065	0.06
Constant for second formula	0.09	0.08	0.07	0.065

When a steel or wrought-iron pipe is pierced with tube holes the maximum allowable stress in the ligaments in lb per sq in. shall not exceed the values given in Table P-5B, and the maximum allowable working pressure shall be computed in accordance with the rule in Par. P-180, provided the tube holes do not pierce the weld in the welded pipe and provided the pressure shall not be greater than that allowed for the unpierced pipe.

TABLE P-5A

VALUES OF FACTOR S TO BE USED IN FORMULAS IN PAR. P-23[1]

Material	Spec. No.	For temperatures in deg F not to exceed 750	800	850	900	950
Seamless medium-carbon steel	S-18	11,500	9160	7520	5650	4000
Seamless low-carbon steel	S-18, S-17	9,000	7020	5800	4630	3440
Fusion-welded steel[2]	S-1	9,000	7200	6070	4950	3600
Fusion-welded steel, Grade B[2]	S-2	8,200	6600	5450	4350	3240
Fusion-welded steel, Grade A[2]	S-2	7,400	5900	4900	3900	2880
Lap-welded steel	S-18	7,000	5580	4630	3690	2720
Butt-welded steel	S-18	5,000	3980	3310	2630	1940
Lap-welded wrought iron	S-19	5,300	4220	3510	2790	2060
Butt-welded wrought iron	S-19	4,500	3580	2980	2370	1750
Brass	S-24	4,500	At temperatures not to exceed 406 F			
Copper	S-23	4,500				

[1] The factor S given in the table is based on the allowable stress for the material used as pipe for temperatures of 750 deg. or over, and the thickness subtraction factor limits the actual working stress in the pipe due to internal pressure to a value less than S in order to allow for cross-strains and mechanical or thermal stresses that cannot be determined accurately.

[2] Fusion welded in accordance with Pars. P-101 to P-111, inclusive.

PAR. P-25. CANCEL REVISION SHOWN IN APRIL ISSUE, AND REVISE PARAGRAPH TO READ:

P-25. *Blow-Off Piping.* Blow-off piping shall be of black wrought iron (not galvanized) or black steel, and shall be as heavy as required for the feed pipe and in no case less than extra strong pipe size.

Pars. P-107 and U-75. Omit.

Pars. P-108 and U-76. Revise Fourth Section to Read:

All connections attached by fusion welding shall be stress-relieved [on vessels requiring stress relief and as required by Par. U-59*b* in all cases specified in Fig. U-16].

Par. P-193*b*. Omit.

Pars. P-194 and U-33. Revise First Section to Read:

The longitudinal joints of a riveted dome 24 in. or over in inside diameter shall be of butt-and-double-strap construction, or the dome may be made without a seam of one piece of steel pressed into shape. In the case of a dome less than 24 in. in diameter for which the product of the inside diameter and the maximum allowable working pressure does not exceed 4000 in-lb, the longitudinal joint may be of the lap type, provided it is computed with a factor of safety not less than 8.

Omit the Last-Section and Replace by the Following:

The attachment of riveted domes and manhole frames to shells or heads of boilers [pressure vessels] shall be designed in accordance with Par. P-268*b* [U-59*b*].

Pars. P-195 and U-36. Insert the Following After the Fourth Section:

All other openings which require reinforcement placed in a head dished to a segment of a sphere shall be reinforced in accordance with Par. P-268 [U-59].

Insert the Following After the Seventh Section:

All other openings which require reinforcement in an elliptical head including a nozzle or ring-type manhole shall be reinforced in accordance with the requirements of Par. P-268 [U-59], and when so reinforced the thickness of an elliptical head may be the same as for a blank head in semi-elliptical form.

Omit the Last Section.

Add the Following Section:

Unreinforced openings in heads shall be governed by the following rules:

(1) The edge of any unreinforced opening, excluding rivet holes, shall come no closer to the line bounding the spherical portion of the head around a manhole than the distance equal to the thickness of the head, and in no case except for water-column connections shall it come within the part formed by the corner radius of a dished head.

(2) The maximum allowable diameter of any unreinforced opening in a head shall not exceed that permitted by the rules in Par. P-268*a* [U-59*a*] for a shell of the same diameter, thickness, working pressure, and material, nor shall it exceed 8 in. in any case.

(3) The minimum distance between the centers of any two unreinforced openings, rivet holes excepted, shall be determined by the following formula:

$$L = \frac{A + B}{2(1 - K)}$$

where L = distance between the centers of the two openings measured on the surface of the head in inches

A and B = diameters of the two openings in inches

K = same as defined in Par. P-268*a* [U-59*a*] for the equivalent shell described in (2)

Par. P-259. Revised:

P-259. A manhole reinforcing ring, when used, shall be of rolled, forged, or cast steel, and shall comply with the requirements of Par. P-268.

Par. P-260. Omit Second Sentence.

Pars. P-261 and U-56. Omit.

Par. P-262. Revised:

P-262. Manhole plates and cover plates shall be of rolled, forged, or cast steel, and their strength, together with that of the bolts and of the yokes, if any, shall be proportioned for the service for which they are intended.

Pars. P-268 and U-59. Revised.

Unreinforced Openings. *a* Plain unreinforced holes, such as threaded openings tapped directly into the shell of the boiler [pressure vessel], drilled holes for the boiler-tube type of connection and studded connections, shall not exceed the diameter given by the charts in Fig. P-27$^1/_2$ [U-3$^1/_2$],[3] nor shall they exceed a diameter of 8 in. in any case. The diameter of a threaded opening shall be taken as that at the root of the thread.

The definitions of the symbols shown in Fig. P-27$^1/_2$ [U-3$^1/_2$][3] are as follows:

d = maximum allowable diameter of openings, in.

D = outer diameter of the shell, in.

t = actual thickness of shell, in.

$$K = \frac{PD}{2ST}$$

P = working pressure, lb per sq in.

S = working stress, lb per sq in., given by Table P-6 [U-3].

When there is a series of unreinforced openings in a boiler [pressure vessel], the efficiency of the ligaments between openings shall be calculated by the rules given in Pars. P-192 and P-193 [of Section I of the Code].

Threaded Connections. All threaded connections 1-in. pipe size or over which conform to the American Pipe Thread Stand-

[3] See Figs. 1 and 2 on pages 368 and 369 of this issue.

TABLE P-5B MAXIMUM ALLOWABLE STRESS IN LIGAMENTS BETWEEN TUBE HOLES IN LB PER SQ IN.

Material	Spec. No.	For temperatures in deg F not to exceed: 700	750	800	850	900	950
Seamless medium-carbon steel	S-18	12,400	11,500	9160	7520	5650	4000
Seamless low-carbon steel	S-18, S-17	9,600	9,000	7020	5800	4630	3440
Fusion-welded steel[1]	S-1	11,000	10,000	8000	6750	5500	4000
Fusion-welded steel, Grade B[1]	S-2	10,000	9,110	7330	6050	4830	3600
Fusion-welded steel, Grade A[1]	S-2	9,000	8,220	6550	5440	4330	3200
Lap- or butt-welded steel	S-18	9,000	8,220	6550	5440	4330	3200
Lap- or butt-welded wrought iron	S-19	9,000	8,220	6550	5440	4330	3200

[1] Fusion welded in accordance with Pars. P-101 to P-111, inclusive.

ard shall have not less than the number of full threads given in Table P-11 [U-6]. For smaller threaded connections there shall be at least four such threads. Other thread standards may be used provided the threaded thickness of the material conforms to Table P-11 [U-6].

If the thickness of the shell of the boiler [pressure vessel] is not sufficient to give such number of threads, a construction shall be employed which will provide at least the required number of threads.

When the maximum allowable working pressure exceeds 100 [125] lb per sq in., connections over 3-in. pipe size shall not be threaded into the wall of the vessel.

Seal welding may be employed either on the outside or the inside of the shell.

Expanded Connections. A pipe or tube connection or forging may be attached by inserting through an opening and expanding into the shell, provided the diameter of such an opening is not greater than that permitted for unreinforced circular openings in this section. Such connections shall be expanded and flared not less than $^1/_8$ in. over the diameter of the tube hole or they may be flared not less than $^1/_8$ in., rolled and beaded, or flared, rolled, and welded. Such tubes shall project through the shell not less than $^1/_4$ in. nor more than $^1/_2$ in. before flaring. Where such tubes enter at an angle, the maximum limit of $^1/_2$ in. shall apply only at the point of least projection. The outside diameter of such a connection shall not exceed 6 in.

Studded Connections. A studded connection with a flat surface machined on the shell for a gasket may be used for attaching flanged fittings, provided the studs are engaged in the shell for a depth of at least the diameter of the stud used. The design and bolting of the flange shall be in accordance with Par. P-299 [of Section I of the Code]. Stud holes shall straddle the center line of the vessel. The equivalent diameter of the opening shall be that determined by the total length of shell removed, including stud holes, if any, on any line parallel to the longitudinal axis of the shell. The equivalent diameter shall not exceed the maximum allowable diameter of an unreinforced opening as given by the rules above, using in Fig. P-27$^1/_2$ [U-3$^1/_2$][3] the minimum thickness of the shell resulting from the machining of the flat surface.

Reinforced Openings. b An opening in the shell of a boiler [pressure vessel] with a diameter greater than the maximum unreinforced opening permitted by section (*a*) shall be provided with reinforcement. Such reinforcement shall consist of one or more reinforcing rings or flanges riveted, welded, or brazed to the shell and/or a tube or pipe extension or fitting welded to the shell and/or welded to or integral with the reinforcing flange. The thickness of each riveted reinforcing flange or ring shall not be less than given in Table P-11$^1/_2$ [U-6$^1/_2$].

TABLE P-11$^1/_2$ [U-6$^1/_2$] MINIMUM THICKNESS REINFORCING RINGS OR FLANGES FOR RIVETED CONSTRUCTION

Thickness of shell plate, in.	Thickness of reinforcing ring or flange, in.
$^1/_8$	$^1/_8$
$^3/_{16}$	$^3/_{16}$
$^1/_4$ to $^{11}/_{32}$	$^1/_4$
$^3/_8$ to $^{13}/_{32}$	$^5/_{16}$
$^7/_{16}$ to $^{15}/_{32}$	$^3/_8$
$^1/_2$ to $^9/_{16}$	$^7/_{16}$
$^5/_8$ to $^3/_4$	$^1/_2$
$^7/_8$	$^5/_8$
1	$^{11}/_{16}$
$1^1/_8$ to 2	$^3/_4$
Over 2	[illegible]

The outside diameter of a riveted reinforcing ring or flange shall not be less than $1^1/_2$ times the diameter of the opening in it.

The thickness of a tube or pipe extension welded to the shell and/or a reinforcing ring or flange shall not be less than that for extra strong [standard-weight] pipe of the same diameter, and shall comply with Par. P-23 [of Section I of the Code].

For nozzle fittings having a bolting flange and an integral flange for riveting or welding, the thickness of the flange attached to the boiler [pressure vessel] shall also be not less than the thickness of the neck of the fitting.

All reinforced circular or elliptical openings shall comply with the following requirements:

(1) On a line parallel to the longitudinal axis of the shell and passing approximately through the center of the opening and through the weakest section of a riveted reinforcing ring or flange, the total cross-section in the complete reinforced opening, including the shell and cross-section of fusion welds if any, and deducting for rivet holes if any, within the limits defined below shall be at least equal to the cross-section obtained by multiplying the shell thickness required by Par. P-180 [U-20], using $E = 0.90$, by twice the diameter of the opening less 2 in. The above-mentioned limits are:

A distance on each side of the center line of the opening equal to the actual inside diameter of the opening in the finished construction;

A distance on each side of the center line of the actual thickness of the shell equal to 3 times such actual thickness or 5 times the thickness of the tube or fitting, whichever is greater (see Fig. A-11 [UA-1]).

When there are two or more adjacent openings, the limits shall not be considered to overlap, and in no case shall any portion of a cross-section be considered to apply to more than one of the two adjacent openings.

(2) On either side of the line parallel to the longitudinal axis of the shell, as determined in (1), the strength of the attachment to the boiler [vessel] of each separate part of a reinforced opening shall be at least equal either to the tensile strength of the cross-sectional area determined by multiplying the shell thickness required by Par. P-180 [U-20], using $E = 0.90$, by the diameter, less 2 in., of the opening in the shell in the finished construction, or to the tensile strength of the cross section of the reinforcement within the above limits, whichever is smaller. For riveted construction, the strength of attachment is the shearing strength of the rivets, and for fusion welded construction it is the strength of the weld in shear or in tension, whichever is smaller.

The unit working shear stress of a weld shall not exceed 0.8 times the allowable working stress in tension [for the class of fusion-welded vessel for which the welding process is suitable].

The size of a fillet weld shall not be less than one-half the thickness of the thinner of the two parts being joined.

Riveted Connections. Materials for riveted openings shall be of rolled, forged, or cast steel.

The strength of the rivets in tension in a flange frame or ring riveted to a drum [vessel], based on the minimum tensile strength given in the specifications, shall be at least equal to that required to resist the stress due to the maximum allowable working pressure with a factor of safety of five.

The tensile stress in the rivets due to the pressure shall be computed in the following ways:

(1) For outside calking the stress shall be equal to the area bounded by the outside calking multiplied by the maximum allowable working pressure.

(2) For inside calking (and with no outside calking) the stress shall be equal to the area bounded by the inside calking multiplied by the maximum allowable working pressure.

The rivets attaching nozzles shall be so spaced as to avoid the possibility of the shell plate failing by tearing around through the rivet holes. This feature shall be checked by applying the rules given in Par. P-193*c* [of Section I of the Code], which bear on the strength where a series of holes are placed in a drum.

Seal welding may be employed in accordance with the procedure in Par. P-257*b* [U-52*b*].

Forge-Welded Connections. Forge-welded connections shall be of forged or rolled steel material, seamless tubing, or forge-welded pipe.

[Forge-welded connections shall be attached by the methods shown in Figs. U-17 and U-18.]

All forge-welded connections shall be stress-relieved in accordance with the procedure given in Par. P-108 [U-76].

Fusion-Welded Connections. Materials for fusion-welded connections shall be in accordance with Par. P-103*b* [U-71*b*].

All connections attached by fusion welding [on Class 1 vessels] shall be stress-relieved.

[All connections attached by fusion welding on Class 2 vessels requiring stress relief shall be stress-relieved.

All connections attached by fusion welding on Class 2 vessels which do not require stress relief shall be stress-relieved except those formed by welding a plain-end pipe, welding neck or nipple directly to the vessel without the attachment of additional material, when the diameter of the opening does not exceed 10 per cent of the outside diameter of the shell. Some such connections are illustrated in Figs. U-16 *A*, *C*, and *D*. Connections formed by welding to the vessel a hydraulic coupling or special forging for a threaded opening not to exceed 3 in. pipe size need not be stress-relieved.

Connections attached by fusion welding on Class 3 vessels need not be stress-relieved.]

[All connections attached by fusion welding to forge welded, riveted, brazed, or seamless vessels shall be stress-relieved in accordance with the requirements for connections on Class 2 vessels which do not require stress-relieving. If any such vessels are to be used for service equivalent to Class 1 fusion welding, then any fusion-welded connection must be stress-relieved.]

Fusion-welded connections [which require stress-relieving and] which are attached to vessels whose seams are of riveted construction shall be fabricated and stress-relieved prior to the making up or attachment of the courses by riveting. [If they do not require stress-relieving and are attached after riveting, the welds shall be located at a distance from the riveted seam at least equal to the diameter of the opening plus 4 times the plate thickness of the shell.]

Fig. P-6 [U-6] illustrates some types of fusion-welded connections which are acceptable.

[*Brazing.* For threaded openings in pressure vessels where brazing is permitted, if the thickness of material in the vessel is not sufficient to give the number of threads specified in section *a*, the openings may be fabricated for a threaded connection by brazing to the shell a plate or a forged boss with inside flange, or any other type of connection described in this section may be used.]

c Typical examples of the application of the above rules are presented in Pars. A-63 to A-68 [UA-10 to UA-16] of the Appendix. (Note: For the full text of these paragraphs, communicate with the Secretary of the Boiler Code Committee.)

PAR. P-300. INSERT THE FOLLOWING AS THE FIRST THREE SECTIONS:

Piping connected to the outlet of a boiler for any purpose and which comes within the Code requirement, shall be attached (1) by screwing into a tapped opening with a screwed fitting or valve at the other end, (2) by screwing each end into tapped flanges, fittings, or valves with or without rolling or peening, (3) by joints of the Van Stone type, (4) by expanding into grooved holes, seal welding if desired. Blow-off piping of fire-tube boilers shall be attached by (1) if exposed to products of combustion, or by (1), (2), or (3) if not so exposed.

Fusion welding for sealing purposes at the juncture of bolted joints may be used.

Welding may be used to attach piping to nozzles or fittings if the rules for fusion welding and forge welding are followed.

PAR. P-310. REPLACE REVISION OF FIRST SENTENCE AS SHOWN IN APRIL ISSUE BY THE FOLLOWING:

The blow-off piping, and any piping or fittings connecting them to the boiler, shall be of black wrought iron (not galvanized) or black steel, and shall be as heavy as required for the feed pipe and in no case less than extra strong pipe size, and shall conform to the requirements of Par. P-300.

PAR. P-315. ADD THE FOLLOWING SENTENCE:

The pipes shall be attached as provided in Par. P-300.

TABLES P-11 AND U-6. CHANGE THE THIRD HEADING IN THE FIRST COLUMN TO READ:

Minimum number of threads required for connection.

CHANGE THE FOURTH HEADING IN THE FIRST COLUMN TO READ:

Minimum thickness or length required to give above number of threads, in.

FIG. P-5.

Omit illustrations *b* and *c;* transfer *a* to Par. P-104.

FIGS. P-6 AND U-16:

Fig. A. Omit reference No. 1
Fig. B. Delete
Fig. C. Eliminate reference Nos. 1 and 2. Also delete text which reads, "Limit to 8 in. maximum"
Fig. D. Eliminate reference Nos. 1 and 2
Fig. E. Delete
Fig. F. Revise to include a welded ring to show connection for a nozzle on the outside above reinforced ring
Fig. G. Include dimension "6*t*" for the overlap as shown in other illustrations
Fig. H. Divide illustration into 2 cuts and change reference numbers
Fig. J. Divide illustration into 2 cuts and change reference numbers
Fig. K. To be revised so that joint looks like that shown in Fig. A
Fig. L. No change
Illustration No. 1. To be omitted
Illustration No. 5. To be revised to show a 45-deg angle.

It has been suggested to omit the formulas for thicknesses given below detail sketches.

Delete headings: "Unreinforced Nozzle Outlets" and "Reinforced Nozzle Outlets."

Delete text which reads: "Stress-Relieving Is Required in Fabricating Designs: B, F, G, H, J, K, and L."

Revise caption to read: "Some Types of Fusion-Welded Nozzle Construction."

FIGS. P-27 AND U-3.

Remove from body of Code and place in Appendix.

PAR. H-35. REPLACE REVISION OF LAST SENTENCE AS SHOWN IN APRIL ISSUE BY THE FOLLOWING:

When the width is 36 in. or less, the distance between the bottom of the boiler and the floor line shall not be less than 6 in., and when any part of the wet bottom is not farther from an outer edge than 12 in., it shall not be less than 4 in.

PAR. H-36. REVISED:

H-36. The minimum size of at least one fire or other access door used in a boiler or setting for boilers 30 in. and over in diameter or width shall be 12 in. by 16 in. or equivalent area, the least dimension being 11 in.

EXEMPTION CLAUSE PRECEDING PAR. U-1. REVISE ITEM (*a*) TO READ:

(*a*) to pressure vessels which are subject to Federal inspection and/or control,

PAR. U-1. REVISED:

U-1. The rules of this Section apply to unfired pressure vessels constructed of materials herein specified which are cylindrical in shape, having a combination of diameter and working pressure such that $(P - 15)(D - 4)$ is greater than 60, and to those vessels having a combination of volume and working pressure such that $(P - 15)(V - 1.5)$ is greater than 22.5,

where P = pressure, lb per sq in.
D = inside diameter of the vessel, in.
V = volume in cu ft.

In the absence of definite rules in this Section on the construction of unfired pressure vessels, the specific provisions of Section I of the Code may be used wherever they apply, and the vessel may then be stamped as conforming with the Code.

TABLE U-1. THE FOLLOWING REVISIONS ARE PROPOSED IN THIS TABLE:

Insert the word "Guaranteed" at the beginning of the title.

Insert the following dimensions under the heading, "Size of Vessel Outlet for Safety-Valve Connections (Nominal pipe size and actual diameters of pipe size, in.):"

$^1/_4$	$^3/_8$	$^1/_2$	$^3/_4$	1
0.364	0.494	0.622	0.824	1.049
$1^1/_4$	$1^1/_2$	2	$2^1/_2$	3
1.380	1.610	2.067	2.469	3.068

Under the heading for gage pressure, the following additions are to be noted for the corresponding diameters of valve:

Diameter of valve (in.)	Gage pressure, lb 50	100	150	200	250	300	350	400	500	600	800	1000	1200	1600	2000	2400
$^1/_4$	12	20	27	33	38	43	48	...	...	...	...	...	...	...	...	...
$^3/_8$	17	27	36	44	51	58	65	72	83	95	115	133	149	176	197	215
$1^1/_4$	...	...	...	...	...	...	...	352	400	443	...	...	...	...	...	...
$1^1/_2$	...	...	...	...	...	...	...	478	528	568	...	...	...	...	...	...

PAR. U-3. ADD THE FOLLOWING:

Each safety valve $^1/_4$ in. in size and larger shall be plainly marked by the manufacturer in such a way that the marking will not be obliterated in service. The maximum allowable pressure at which the safety valve may be operated shall be cast or stamped on the body of the valve. The marking may be stamped or cast on the casing or stamped or cast on a plate or plates securely fastened to the casing and shall contain the following marking:

a Name or identifying trademark of the manufacturer.

b *Size* .... *in.*
The pipe size of valve inlet. (Where the valve inlet is not threaded the initial diameter of the inlet shall not be less than the inside diameter of a standard pipe of the same normal diameter as that of the valve.)

c *Pressure* .... *lb*
Pressure at which the valve is set to blow.

d *B.D.* .... *lb*
Blow down. (Difference between the opening and closing pressures—minimum 2 per cent.)

e *A.S.M.E. Std.*

PAR. U-7. ADD THE FOLLOWING:

except that safety valves $^3/_4$ in. in size and less may have drain holes as large as possible but not less than $^3/_{16}$ in. diameter.

PAR. U-12. ADD THE FOLLOWING SENTENCE:

If, in the development of the art of pressure-vessel construction, other materials than those herein described become available, specifications may be submitted for consideration.

PAR. U-55. REVISED:

U-55. A manhole reinforcing ring, when used, shall be of rolled, forged, or cast steel, and shall comply with the requirements of Par. U-59.

PAR. U-57. OMIT.

PAR. U-58. REVISED:

U-58. Manhole plates and cover plates shall be of rolled, forged, or cast steel, and their strength, together with that of the bolts and of the yokes, if any, shall be proportioned for the service for which they are intended.

PAR. U-61. ADD THE FOLLOWING AS SECTION *b*:

b When plates less than $^1/_4$ in. thick are used, the manufacturer must mark each vessel in some permanent manner which will enable him to identify the heat from which the sheet in each tank has been rolled.

PAR. U-64. INSERT THE FOLLOWING AS SECOND SENTENCE:

Gas storage vessels which are too large to withstand safely the weight of the large mass of water required to fill them for hydrostatic test, may be tested by compressed air at a pressure not to exceed the maximum allowable working pressure of the vessel.

PAR. U-65. REVISE LAST SENTENCE TO READ:

A data sheet shall be filled out and signed by the manufacturer and the inspector. This data sheet, together with the stamping on the vessel shall be a guarantee by the manufacturer that he has complied with all the requirements of this section of the Code.

PAR. U-66. INSERT FOLLOWING AS FOURTH SENTENCE OF FIRST SECTION:

Such separate name plates shall be used on all vessels constructed of plate less than $^1/_4$ in. thick instead of stamping the vessel itself.

INSERT THE FOLLOWING AS SECOND SECTION:

After obtaining the stamp to be used when vessels are to be constructed to conform with this section of the A.S.M.E. Boiler Code, a state inspector, or a municipal inspector of any state or municipality that has adopted the code, or an inspector employed regularly by an insurance company and who is qualified under the rules of such states or municipalities to inspect such vessels, is to be notified that an inspection is to be made; and he shall inspect such vessels during construction and after completion.

PAR. U-68*a*. ADD THE FOLLOWING SENTENCE:

When there are several vessels being welded in succession or at any one time, whose plate thicknesses fall within a range of $^1/_4$ in., only two sets of test plates for each 200 ft of longitudinal and circumferential seams need be welded for the entire group of vessels, provided they are welded in the same way as the joints in question.

PAR. U-68*i*. REVISE FIRST SENTENCE TO READ:

i Non-Destructive Tests of Vessel. For plate thicknesses $2^1/_2$ in. and less, every portion of all longitudinal welded joints of the structure, including the intersections with the girth joints, shall be radiographed by a sufficiently powerful X-ray apparatus under a technique which will determine quantitatively the size of a defect with a thickness greater than 2 per cent of the thickness of the base plate. Twenty-five per cent of the length of each circumferential welded joint shall be radiographed at not less than four equally spaced intervals around the circumference. Where any one radiograph fails to comply with these requirements, all parts of all circumferential seams shall be radiographed.

PAR. U-70. REVISE SECOND SECTION TO READ:

For single-welded butt joints and for double full-fillet welds for longitudinal joints, the maximum unit joint working stress ($S \times E$) shall be as follows: For material of thickness of less than $^1/_4$ in., 5600 lb per sq in.; for material of thickness of $^1/_4$ in. to $^3/_8$ in., 7000 lb per sq in.

Lap joints as provided for in Par. U-73*a* shall not be used in the construction of vessels for the storage of gases of any kind at pressures in excess of 100 lb per sq in., nor for the storage of any liquid at a temperature exceeding its boiling point at atmospheric pressure.

PAR. U-86. ADD THE FOLLOWING AS SECTION *b:*

b Resistance Welding. Where the entire area is welded simultaneously, electric-resistance butt welding, or butt welding where thermit is employed as the heating element without the introduction of extraneous metal, may be used and the ultimate strength of the joint taken as 35,000 lb per sq in. as in the case of forge welding. Either method may, upon the request of a manufacturer who submits proper scientific data and evidence, be given a higher rating by the Boiler Code Committee than for forge welding, provided that an authorized inspector may demand a test of any one of the welded articles he may select for the purpose, and if, after witnessing such a test, he shall doubt the advisability of using the assigned rating for the weld, the case shall be referred to the Boiler Code Committee for its decision.

PAR. U-87. INSERT THE FOLLOWING AT THE END OF THE FIRST SENTENCE OF THIS PARAGRAPH:

The structure shall be stress-relieved in accordance with the procedure given in Par. U-76.

IN THE FIRST LINE OF THIS PARAGRAPH, OMIT THE WORD "ENTIRE."

PARS. U-88, U-89, AND U-93. OMIT.

PAR. U-94. REVISED:

U-94. When properly brazed the strength of a joint may be calculated on a maximum unit working stress of $S \times E = 9900$ lb per sq in. (see Par. U-20).

FIGS. U-8 AND U-14.

Change the limit of corner radius of bend-test specimen from "$0.1t$" to "not over $0.1t$."

FIG. U-13. Replace the dimension "about 6 in." by a reference letter "A," with the definition that "A is to be about 3 in. for $^1/_4$-in. plate and as close together as practicable for greater thicknesses."

Engineer Registration Laws

(*Continued from page 322*)

award of professional degrees, for presentation to clients when soliciting contractors for professional services, for presentation to employers when applying for positions, etc.

6 The Bureau should be administered by a committee of the National Council of State Boards of Engineering Examiners, assisted by an advisory board of representatives of national engineering societies. All details of organization, finance, personnel, location, and administration to be worked out by the committee.

ENGINEERING EDUCATION

The question of qualifications for registration is intimately connected with the question of engineering education. The records of the Office of Education of the United States Government show that engineering is the only learned profession which does not have a list of "approved" engineering educational institutions. Most of the state engineer registration laws require the state boards to decide whether or not an engineering school is an "approved" one, and therefore whether or not its graduates can be recognized by the state law.

In this respect the National Council of State Boards of Engineering Examiners made in October, 1931, the following decision:

That its Committee on Accredited Schools be authorized to invite representatives of other interested agencies, including the national engineering societies and the Society for the Promotion of Engineering Education, to join here in a joint committee, to set up an improved set of standards for accredited schools, and for formulating a definite program for listing accredited schools.

This committee has a list of 135 engineering educational institutions which it has in the past recommended to state boards for acceptance as "approved."

Correspondence

Research Must Go On!

TO THE EDITOR:

The train of logic shows the scientist and the engineer to be responsible for the machine age and hence, it might be implied, for its social complications. In order to dispel these difficulties and make clear sailing through rocky economic seas, one does not have to agree with a certain group of extremists who reason that, because machinery and processes have over-

produced the necessities of life, man should return to primitive handicraft. The significance of work lies neither in idealizing nor in deprecating it. Man works to better his material status, and improved mechanism of production cannot ultimately turn out to be other than helpful to this end. In the search for ways and means to put the brakes upon production during a period of business extravagance and thus regain symmetry of form in the tracing of business cycles, manufacturers should never ignore the possibility that the solution of the problem may lie in the development of present industrial processes and in the invention of new tools. There is no actual likelihood that the tempo of modern life will be permanently retarded. The historical presumption is against it. If, perforce, acceleration remains the rule, new technical visions must be dimensioned on blueprints and new fields searched by the laboratory methods of science. The ultimate problem is not so much technical as sociological—the beneficial employment of leisure time.

In the meantime, when leisure is enforced by stern necessity, it would appear reasonable to expect thoughtful management to oppose every argument for the reduction of the effective personnel in the experimental departments of our machine and process industries. It is with these very men that the hope lies of planning other advances in scientific development quite as unforeseen as those made during the past few decades. While we are plodding through financial quagmires and trying to divide the visible employment among the genuine employables, it would seem to be the part of wisdom to continue research work which, through the perfection of new methods and processes, will create new human needs. Perhaps even the investment bankers will grow to realize the value of genuine and conscientious engineering staffs.

Mental poise and tempered judgment may be rocked and even unbalanced by the economic issues occasionally presented to employers through the monthly records of their cost departments. During a period of vanished profits it is not surprising that the urge for safety leads some makers of machines and appliances into doubtful economies in their payrolls. Liberality of outlook and length of vision may be blurred by the emotional strains of responsibility. Lowell, however, has reminded us somewhere that the most-dreaded misfortunes never arrive.

WM. S. CONANT.[1]

Invention, Unemployment, and Patent Control

TO THE EDITOR:

On page 154 of your February issue, comment is invited on the letter contributed by Bertell W. King about patented improvements displacing workers.

The purpose of the patent statute is to induce inventors to disclose their improvements to the public in return for seventeen years of monopoly. The tremendous number of worthless patents applied for each year would seem a satisfactory demonstration that seventeen years is sufficient, and that there is not the slightest occasion for an increase to fifty years as advocated by Mr. King.

If the Government were to have control over all patents and to issue licenses to any applicant, there would be no monopoly advantage to any one willing to promote the patent. Under such a plan patented devices would not be developed. It is the monopoly feature that constitutes the reward. Without it, license fees would not be forthcoming save for exceptionally useful devices.

Mr. King's conception of a patent-created millionaire is faulty. The millionaire does not usually roll in lavish living expenditures. He is much more likely to be a producer whose million is invested in equipment or factories useful to all of us and creating employment for the workers.

Progress in industry comes through displacement of workers by innovations. The progress results from the fact that their displacement frees them for useful work elsewhere, when their services are no longer required in their former assignments. Such displacement rarely results in permanent unemployment. Labor turnover in manufacturing industries averages 50 per cent a year in normal times, which means that the average worker holds his job but two years.

Security of employment is incompatible with industrial progress. It is the shift of workers that accomplishes progress. Our economic plan is based on production increasing faster than population. There is then increasingly more to divide, and incomes rise. This applies equally to wages. They have risen steadily over long periods for centuries past. With rising wages, demand for labor expands.

Under these conditions there should be a job for any one at any time. And there would be, but unfortunately attempts to stabilize prices and wages tend to concentrate business fluctuations in the other industries, with occasional wild variations reacting on the stabilized industries until all must be deflated because of the selfishness of a few.

DANIEL B. LUTEN.[2]

Indianapolis, Ind.

Wanted: Industrial Speed Control

TO THE EDITOR:

Our fine machine of civilization, largely the product of the engineering mind, is equipped with an accelerator but has no brake.

For three hundred years we have used the accelerator; during the last score we have come to regard it as the center of modern civilization: more men, more machines, more output per man, more output per machine, labor-saving devices, time and motion studies, line assemblies; more, faster ever more, ever faster.

Suddenly we had enough. As a people we were supplied—better and more abundantly than any people were ever supplied before. We were at the top of the hill with the flat country before us. For the first time in three hundred years we needed a real speed control—and only had an accelerator. Advertising, salesmanship, efficiency, reduced costs of production; all accelerator parts were offered.

It is quite clear:

That we can produce more than we can consume.
That what we can produce we will not import.
That other countries are in much the same way, so we cannot count on relief through export.
That we must somehow adjust to a new world where the production of new wealth will not serve to engage all of human energies.

Can the engineer assist in, even guide, this adjustment?

WANTED: A serviceable speed control in exchange for a first-class industrial speed accelerator (in A-1 condition but not now in use).

GEORGE W. MUNRO.[3]

West Lafayette, Ind.

[1] Consulting Engineer, Washington, D. C., Mem. A.S.M.E.

[2] President, Luten Engineering Company. Mem. A.S.M.E.

[3] Professor of Thermodynamics, Purdue University. Mem. A.S.M.E.

Books Received in the Library

Accountants' Handbook. Edited by W. A. Paton. Second edition. Ronald Press Co., New York, 1932. Leather, 5 × 8 in., 1873 pp., diagrams, charts, tables, $7.50. Intended to give business men and engineers, as well as accountants, a comprehensive, reliable description of accepted practice in all branches of commercial and financial accounting. Engineers will find the section on the principles of depreciation and the extensive tables of rates of depreciation of special interest. The new edition is three hundred pages larger than the first and is an entirely new publication.

Advanced Mechanics of Materials. By F. B. Seely. John Wiley & Sons, New York, 1932. Cloth, 6 × 9 in., 331 pp., illus., diagrams, charts, tables, $5. This textbook is intended for advanced undergraduate and first-year graduate students, and continues the subject beyond the usual course in the strength of materials. It aims to show the limitations of the ordinary formulas, to consider the conditions under which the limitations are significant, and to extend the subject to more complex topics. It also endeavors to give a more comprehensive view of the fundamental concepts and methods used in stress analysis, and to acquaint the student with the principal sources of information upon the subject.

Airplane Construction and Repair. By J. E. Younger and N. F. Ward. McGraw-Hill Book Co., New York, 1931. Cloth, 5 × 8 in., 433 pp., illus., diagrams, charts, tables, $3. This textbook, designed for vocational schools and home study, presents the information needed by those in training for service and repair work on airplane structures. The text is a clear and simple presentation of fundamentals, accompanied by problems and experiments.

American Society for Testing Materials. Proceedings, vol. 31, parts 1 and 2, 1931. Philadelphia. Paper, cloth, half leather, 6 × 9 in., illus., diagrams, charts, tables; pt. 1, 1119 pp.; pt. 2, 1027 pp.; $5.50 paper, $6 cloth, $7 half lea., each part. These two large volumes contain a mass of useful matter upon the properties of engineering materials and methods of testing, resulting from the activities of the various committees of the society and of its individual members. The first volume contains the reports of the committees, the tentative standards prepared by them, and a number of papers upon topics closely related to their work. The second volume contains the papers presented at the annual meeting, among which are extensive symposiums upon malleable-iron castings, the weathering characteristics of masonry materials, abrasion testing of rubber, and the economic significance of specifications for materials.

American Society of Heating and Ventilating Engineers Guide, 1932. Published by the Society, New York. Leather, 6 × 9 in., 876 pp., illus., diagrams, charts, tables, $5. The Guide is a reference book of information upon heating and ventilating, prepared by a number of specialists and issued by the society. It presents concisely much definite information upon heating and ventilating practice and upon equipment and accessories, compiled from the most reliable sources, and will prove useful to engineers, manufacturers, and building owners. The volume also contains catalogs of manufacturers of equipment.

Angewandte Hydromechanik. By W. Kaufmann. J. Springer, Berlin, 1931. Paper and bound, 6 × 10 in., 232 pp., diagrams, charts, tables; paper, 12.50 r.m.; bound, 14 r.m. The object of this book is to give engineers having only an average knowledge of mathematics and mechanics, and who are primarily interested in the applications of hydromechanics, an account of the underlying theories and methods of the subject, and a concise, practical account of the principal applications. The first volume is an introduction to the theory. It includes a brief outline of hydrostatics and a more elaborate discussion of the theory of hydrodynamics, in which both ideal and viscous fluids are considered.

Applied Gyrodynamics. By E. S. Ferry. John Wiley & Sons, New York, 1932. Cloth, 6 × 9 in., 277 pp., illus., diagrams, charts, tables, $4. The purpose of this work is "to bring gyrodynamics out from behind the integral signs and to present it to the acquaintance of engineers and students having the mathematical equipment of the ordinary graduate of engineering or physics." It develops the laws underlying the gyroscopic devices used in industry and considers such important devices as the gyrohorizon, the gyrosextant, the gyrocompass, and gyrostabilizers for ships and monorail cars. Numerous problems illustrate the practical use of the equations derived from the laws.

Applied Wing Theory. By E. G. Reid. McGraw-Hill Book Co., New York, 1932. Cloth, 6 × 9 in., 231 pp., illus., diagrams, charts, tables, $3. The purpose of this book is to provide a brief but usefully complete presentation of those phases of aerodynamic theory which are of fundamental importance in airplane design, in a form which can be readily followed by engineers and will not demand advanced training in mechanics and mathematics. The book is based upon Prandtl's classic paper, supplemented by the work of other investigators, the intention being to present this material in a more elementary and readable form.

Über die Ausbreitung der von Grosskolbenmaschinen Erzeugten Bodenschwingungen in die Tiefe. By G. Bornitz. J. Springer, Berlin, 1931. Paper, 7 × 10 in., 44 pp., illus., diagrams, charts, tables, 15 r.m. This book differs from others on engine vibrations by including measurements of the extent to which these are apparent far below the surface of the earth. The manner in which these vibrations are propagated upon the surface and below ground were carefully measured at two mines, the coefficients of absorption were determined, and the influence of different kinds of soil and rock upon the amplitude of vibrations was investigated.

Aviation Handbook. By E. P. Warner and S. P. Johnston. McGraw-Hill Book Co., New York and London, 1931. Leather, 5 × 7 in., 715 pp., diagrams, charts, tables, $7.50. This volume follows the well-known plan of handbooks upon other branches of engineering, and, like them, is designed to supply constantly used information in convenient form for quick reference. It aims to give authoritative data on the theory of heavier-than-air craft, structural materials, standard parts, engines, equipment, and other subjects of importance to engineers and designers.

Beitrage zur Geschichte der Technik und Industrie, vol. 21. Edited by C. Matschoss. V.D.I.-Verlag, Berlin, 1931–1932. Cloth, 8 × 12 in., 188 pp., illus., diagrams, maps, tables, 10.80 r.m. The twenty-first volume of this annual of engineering history contains a number of valuable papers, a review of articles published elsewhere, reports on existing ancient engineering works and on museums of industry, and a bibliography of historical publications of the year. Among the subjects of essays are: The discovery of magnetic induction, the development of electric heating during the nineteenth century, early knowledge of the magnetic compass, the development of reinforced concrete, and the history of hydraulic works in China.

Die Dampfturbinen, ihre Berechnung und Konstruktion. By G. Flügel. J. A. Barth, Leipzig, 1931. Paper and bound, 7 × 10 in., 324 pp., diagrams, charts, tables; paper, 31.05 r.m.; bound, 33.30 r.m. This book presents a concise yet comprehensive and systematic discussion of the problems that arise in the design and construction of steam turbines, with emphasis upon their theoretical aspects. It is intended both for students and engineers, especially those interested in design, and aims to occupy a middle position between elementary texts and such large treatises as that of Stodola. An appendix on gas turbines is included.

Die Dampfturbinen. Part 1. Theorie der Dampfturbinen. (Sammlung Göschen 274.) By C. Zietemann. Walter de Gruyter & Co., Berlin and Leipzig, 1932. Part 2. Auflage. Cloth, 4 × 6 in., 140 pp., diagrams, charts, tables, 1.80 r.m. This book, the first of three upon steam-turbine design and construction, is devoted to the theory of steam turbines. The properties of steam, flow from orifices, methods of utilizing the energy of steam, efficiency, etc., are discussed briefly, yet effectively. There is a brief bibliography.

Dieselmaschinen V. Sonderheft der VDI-Zeitschrift. V.D.I.-Verlag, Berlin, 1932. Paper, 8 × 12 in., 156 pp., illus., diagrams, charts, tables, 7.50 r.m. This "special number" contains thirty-seven articles upon new developments in the construction of Diesel engines. Most of these have been selected from those published in the *Zeitschrift des Vereines deutscher Ingenieure* during the past three years, but others appear for the first time. Among them are papers on marine engines, automobile engines and locomotives, on thermodynamic researches, engine operation, fuel injection, and on accessories. The book is a convenient handbook of up-to-date information.

Earthquake Damage and Earthquake Insurance. By J. R. Freeman. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 904 pp., illus., charts, maps, tables, $7. Dr. Freeman pre-

sents a great amount of information upon the occurrence of earthquakes and the damage caused by them, which he has collected from published reports and by personal observations. This information is arranged to meet the needs of the structural engineer interested in the design of earthquake-resistant structures. In addition, he discusses the problem of earthquake insurance and attempts to find a rational basis for rules and rates of premium. The book is a comprehensive review of present knowledge of earthquakes and methods of safeguarding life and property, which will be of value to all structural engineers.

ECONOMICS OF PUBLIC UTILITIES. By L. R. Nash. Second edition. McGraw-Hill Book Co., New York and London, 1931. Cloth, 6 × 9 in., 508 pp., charts, tables, \$4. The aim of this book is to provide in one volume a comprehensive treatment of the underlying economic facts which govern the public utility, considered as a business. This edition has been carefully revised and a chapter upon holding companies added. New material has also been added upon political activities and agitations against public utilities, legislation on interstate transportation, natural-gas movements, and electric-power transmission.

ELEMENTS OF MACHINE DESIGN. By W. Collins. Humphrey Milford, Oxford University Press, London, 1931. Cloth, 6 × 9 in., 248 pp., diagrams, charts, tables, \$5. A textbook for engineering students which discusses briefly the materials of machines, the processes for shaping these materials, and the connection of machine parts. The mathematical analysis of the internal stresses is also discussed, and methods are given for analyzing and comparing machine parts.

EXPERIMENTAL MECHANICAL ENGINEERING. Vol. 1, Engineering Instruments. By H. Diederichs and W. C. Andrae. John Wiley & Sons, New York, 1930. Cloth, 6 × 10 in., 1082 pp., illus., diagrams, charts, tables, \$8. This work is a completely rewritten text based upon Carpenter and Diederichs's "Experimental Engineering," intended for students and practicing engineers. The present volume deals with the construction, calibration, and use of engineering instruments for measuring length, time, speed, pressure, temperature, work, power, etc., for fuel and gas analysis, for measuring fluids, and for testing lubricants. The methods in use are described, their theory explained, and various commercial forms of instruments are presented. Many references are cited.

FLÜSSIGKEITSGETRIEBE AN SPANGEBENDEN WERKZEUGMASCHINEN. By E. Preger. V.D.I.-Verlag, Berlin, 1932. Paper, 6 × 8 in., 88 pp., illus., diagrams, charts, 8 r.m. By means of a concise text and a large number of drawings and photographs, this little book gives an interesting review of the present status of hydraulic drives for machine tools. General arrangements and the design of parts are both described, and the requirements, method of operation, and uses of the drives are explained.

FORSCHUNGSHEFT 351. DIE WÄRMEÜBERTRAGUNG BEI ZÄHEN FLÜSSIGKEITEN IN ROHREN. By H. Kraussold. V.D.I.-Verlag, Berlin, 1931. Paper, 8 × 12 in., 20 pp., illus., diagrams, charts, tables, 5 r.m. Gives the results of an investigation of heat transfer for oils in pipes. A lubricating oil and a transformer oil were tested. The results were compared with those of other investigators.

FORSCHUNGSHEFT 352. ÜBER DEN SCHMIERVORGANG IM GLEITLAGER. By W. Nücker. V.D.I.-Verlag, Berlin, 1932. Paper, 8 × 12 in., 24 pp., illus., diagrams, charts, tables, 5 r.m. Extensive tests were made of the behavior of lubricants in plain bearings under various operating conditions, with precise measurements of friction, load, temperature, and film thickness. The lubricants were found to obey hydrodynamic laws, and the experimental results agreed with theoretical conclusions. The testing plant is described fully and the experimental results given in detail.

GRAPHIC STATICS. By S. Fairman and C. S. Cutshall. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 145 pp., diagrams, charts, tables, \$1.75. The distinguishing feature of this text, according to its authors, is the grouping in one volume of three important topics: trusses and bents, cranes and dredges, and machines. The book represents the course offered to engineering students at Purdue University.

GRUNDZÜGE DER SCHMIERTECHNIK. By E. Falz. J. Springer, Berlin, 1931, Second edition. Cloth, 6 × 9 in., 326 pp., illus., diagrams, charts, tables, 26.50 r.m. A comprehensive treatise on lubrication, intended for machine builders, operating engineers, and manufacturers. The aim of the author is to present the principles underlying successful lubrication in a practical way and to show how the facts ascertained by theoretical investigations may be utilized in practice. Numerous practical examples of calculations are given. The new edition has been enlarged and rewritten to a considerable extent.

HUMAN ENGINEERING. By H. Myers. Harper Brothers, New York and London, 1932. Cloth, 6 × 8 in., 318 pp., tables, \$3. The author, a physician and management engineer, with experience as manager of personnel for several corporations, discusses the management of employees, the relations of workers with each other, matters of health and hygiene and other topics pertaining to personnel problems. His conclusions and methods are presented in effective, readable form.

INDEX TO A.S.T.M. STANDARDS AND TENTATIVE STANDARDS. American Society for Testing Materials, Philadelphia, 1931. Paper, 6 × 9 in., 103 pp., free. This combined index, which covers all standards of the Association in effect in September, 1931, and tells in which publication they can be found, makes it easy to determine whether a specification exists on any particular subject and where it may be found.

INTERNAL COMBUSTION ENGINE. By D. R. Pye. Oxford University Press, New York; Clarendon Press, Oxford, England, 1931. Cloth, 6 × 10 in., 250 pp., diagrams, charts, tables, \$4. The purpose of this volume, according to its author, is to set down the principles which underlie the design and operation of the engine, rather than to supply the information upon a host of details which a practicing designer must have at call. Details of design are mentioned only when they influence or illustrate principles, and the book is primarily for the student, though it aims to give the groundwork of a practical knowledge of the subject as well as a grasp of principles.

INTRODUCTION TO THE HISTORY OF SCIENCE. Vol. 2, in two parts. From Rabbi Ben Ezra to Roger Bacon. By George Sarton. Published for the Carnegie Institution of Washington, as Publication No. 376, by Williams & Wilkins Co., Baltimore, 1931. Cloth, 7 × 11 in., 1251 pp., \$12. In these volumes Dr. Sarton extends his masterly survey of the growth of scientific thought and achievement over the twelfth and thirteenth centuries. The author has aimed to provide an intellectual map of the Middle Ages, with full indication of the sources. The result is an inventory of medieval science, East and West, on a scale never before attempted, which will be indispensable to every student. The book is a marvel of industry and erudition.

KERBWIRKUNG AN BIEGESTÄBEN. By G. Fischer. V.D.I.-Verlag, Berlin, 1932. Paper, 6 × 9 in., 64 pp., illus., diagrams, charts, tables, 6.35 r.m. This is an investigation of the effect of notches upon the fatigue resistance of bars subjected to bending stresses, and particularly of the deformations and stresses at the vertex of the notch. The influence of the depth of notch, the fillet at the vertex, the size of semicircular notches, and the angle of vee notches were carefully studied and equations obtained which express the results. The results are presented in form for use by designers.

LUFTFAHRTFORSCHUNG, Vol. 9, No. 3, pp. 85–134. Zur Berechnung auf Knickbiegung beanspruchter Flugzeugholme. By A. Teichmann. R. Oldenbourg, Berlin and Munich, 1931. Paper, 8 × 12 in., diagrams, charts, tables, 9.40 r.m. This report, emanating from the airplane-testing laboratory in Berlin, gives a more accurate method for calculating the bending stresses in airplane spars. The method includes consideration of the effects of the ribs and the warping of the surfaces upon the stiffness of the spars, and tells how these effects may be calculated accurately.

DIE MASCHINELLEN UND ELEKTRISCHEN EINRICHTUNGEN DES ZWEITEN AUSBAUS DER WASSERKRAFTANLAGEN DER MITTLERE ISAR A.-G. DAS WERK PFROMBACH. (Veröffentlichungen der Mittlere Isar A.-G., München. Heft 5.) R. Oldenbourg, Munich and Berlin, 1931. Paper, 9 × 13 in., 31 pp., illus., diagrams, charts, 4.80 r.m. Contains a description of the great Pfrombach power plant, the final step in the utilization of the Isar below Munich, completed in 1928. The account, written by the chief engineer, H. Graner, describes the electrical and mechanical equipment.

MÉCANIQUE, ÉLECTRICITÉ ET CONSTRUCTION APPLIQUÉES AUX APPAREILS DE LEVAGE. Vol. 3, Les Grues Terrestres et Flottantes. By L. Rousselet. Dunod, Paris, 1932. Paper and bound, 7 × 11 in., 590 pp., illus., diagrams, charts, tables, 210 francs; bound, 223 francs. An extensive treatise upon the construction of land cranes and floating cranes. Special attention is paid to the question of stability and much space is given to methods of predetermining this for different types of cranes. A wide variety of cranes is discussed, and the application of these methods to them is fully illustrated.

CURRENT MECHANICAL ENGINEERING LITERATURE

Selected References From The Engineering Index Service

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ACCELEROMETERS

AUTOMOBILE. Das Messen von Beschleunigungen im Kraftwagenbetriebe, J. Geiger. Automobiltechnische Zeit v 35 n 2 Jan 25 1932 p 31–7. Operating principles of instruments for recording acceleration characteristics of automobiles; mathematical analysis of damping requirements.

AIRPLANE ENGINES

FRICTION. Die Reibungswiderstaende des Flugmotors, K. Loehner. Zeit Fuer Flugtechnik und Motorluftschiffahrt v 23 n 2 Jan 28 1932 p 51–4. Experimental determination of frictional losses and losses due to flow resistance during intake and exhaust strokes; data for BMW 6-cyl and Curtiss D-12 engines.

FUEL INJECTION. Pratt and Whitney's New Fuel Injection System, A.V.D. Willgoos. Aviation Eng v 6 n 2 Feb 1932 p 22–3 and 43. Operation of system providing for direct injection of atomized fuel into cylinders and eliminating necessity for carburetor, preheaters, and hot spots; fuel-injection nozzles located in front of cylinder heads and connected to pumps by means of steel pipes of uniform length.

AIRPLANES

AUTOGIROS. See *Autogiros*.

DESIGN. Die Entwicklung schneller Post- Und Personen-Flugzeuge fuer den deutschen Luftverkehr, E. Schatzki. Zeit fuer Flugtechnik und Motorluftschiffahrt v 23 n 1 Jan 15 1932 p 1–6. Development of fast mail and passenger planes for German air lines; comparison of design and performance of representative German and American airplanes with graphs and tables illustrating relation between speed and power loading, maximum speed and landing speed, etc.

Practical Efficiencies of Airplanes, F. E. Alger. Aero Digest v 20 n 1 Jan 1932 p 56. Use of product of power loading, speed-range ratio, and load-weight ratio as index value; index numbers of some approved-type American planes.

HELICOPTERS. See *Helicopters*.

MILITARY. Vickers "Jocky" Interceptor Fighter. Flight v 24 n 1206 Feb 5 1932 p 108–10; see also Aeroplane v 42 n 5 Feb 3 1932 p 194. Specifications and performance data of low-wing cantilever monoplane of all-metal construction equipped with 530-hp Bristol "Mercury" IV S.2; span 32 ft 8 in.; weight empty 2377 lb; gross weight 3270 lb; wing loading 21.8 lb per sq ft, power loading 6.16 lb per hp; maximum speed 238 mph at altitude of 19,680 ft.

PROPELLERS. Automatic Variable Pitch Airscrew, H. C. H. Townend. Roy Aeronautical Soc—J v 36 n 254 Feb 1932 p 111–26. Wind-tunnel experiments on variable-pitch airscrew which changes pitch automatically by resultant effect of centrifugal and aerodynamic forces; tentative design for model screw.

Experiments with Intubed Propellers, L. Stipa. Nat Advisory Committee Aeronautics—Tech Memo n 655 Jan 1932 11 p 16 supp plates. Wind-tunnel tests show that efficiency of propeller in presence of venturi-tube fuselage is greater than that of isolated propeller; efficiency of propeller integral with venturi-tube fuselage is greater than that of isolated propeller or of propeller in presence of same fuselage. Translated from Aerotecnica Aug 1931.

Resonance Vibrations of Aircraft Propellers, F. Liebers. Nat Advisory Committee Aeronautics—Tech Memo n 657 Feb 1932 44 p 5 supp plates. Mathematical analysis of resonance vibrations caused by unequal impacts of propeller blades; formula for calculating bending frequencies in terms of revolution speed for all propellers of whatever dimensions, with any ratio of hub radius to blade length; numerical examples. Translated from Luftfahrtforschung May 16 1930.

TAILLESS. Die Bedeutung der schwanzlosen Bauart im Flugzeugbau, M. Schrenk. VDI Zeit v 76 n 3 Jan 16 1932 p 63–6. Advantages of tailless design with particular regard to stability, maneuverability, and dynamic characteristics.

WINGS. Beanspruchung von Flugzeugfluegeln durch Boeen, H. G. Kuessner. Zeit fuer Flugtechnik und Motorluftschiffahrt v 22 n 19 and 20 Oct 14 1931 p 579–86 and Oct 28 p 605–15; see also translation in Advisory Committee Aeronautics—Tech Memo v 654 Jan 1932 38 p 17 supp plates. Study of stresses produced in airplane wings by gusts; equations of motion and stress on airplanes in vertical gusts; spatial problem, effect of elasticity of wing; approximate calculation of gust stress of four airplanes.

ALLOY STEELS

PROPERTIES. Einsatzstaehle, E. Eichwald. Automobiltechnische Zeit v 35 n 3 Feb 10 1932 p 59–64. Physical properties and use of principal types of alloy steel with instructions for heat treatment; properties of Krupp nitriding steel.

ALLOYS

ALUMINUM. See *Aluminum Alloys*.

BEARING METALS. See *Bearing Metals*

BRASS. See *Brass*.

HEAT-RESISTING. Heat-Resisting Alloys, J. F. Kayser. Foundry Trade J v 45 n 802 Dec 31 1931 p 412 and 414. Properties of heat-resisting alloys, particularly chromium-nickel-iron alloys; resistance to oxidation; effects of reducing atmospheres. Before Inst Brit Foundrymen.

ALUMINUM ALLOYS

CHLUMIN. New Aluminium Light Alloy "Chlumin," I. Iitaka. Soc Mech Engrs Japan—J v 33 n 4 Dec 1930 p 203–8. "Chlumin" has density of 2.71; resistance to seawater corrosion superior to commercial pure aluminum; easily machined, cast, and rolled; results of corrosion tests and data on physical properties. (In English.)

AUTOGIROS

BUHL. Buhl Pusher Type Autogiro, M. Haifter. Aviation Eng v 6 n 2 Feb 1932 p 24 and 32. Design of autogiro equipped with Continental 165-hp 7-cylinder radial air-cooled engine; rotor blades are 24 ft long.

AUTOMOBILE ENGINES

DIESEL. See *Diesel Engines* (Automotive).

PISTONS. Der Diamant in der Kolbenbearbeitung, K. Seitter. Werkstattstechnik v 26 n 1 Jan 1 1932 p 1–4. Mass production of aluminum-alloy pistons by means of diamond cutting tools; special boring machine for wristpin bearings; multiple tool holders for piston-ring grooves.

AUTOMOBILES

STEAM. Et la vapeur? H. Petit. Vie Automobile v 28 n 987 Feb 10 1932 p 53–6. Possibilities of reciprocating steam engine and steam turbine for automotive purposes with particular regard to advantages over internal-combustion engines due to recent improvements in steam generation.

TESTING. Technische Auswertung der Standard-30-Tagefahrt. Automobiltechnische Zeit v 35 n 1 Jan 10 1932 p 4–6. Tabulated test results for representative German makes containing data on fuel consumption, operating costs, weights, acceleration, types of repairs, etc.

BEAMS

BENDING STRESSES. Bemerkung zur Interpolation und zur Naeherungstheorie der Balkenbiegung, G. Polya. Z fuer Angewandte Mathematik und Mechanik v 11 n 6 Dec 1931 p 445–9. Theoretical mathematical discussion on interpolation and approximate theory of beam flexure, with special reference to Birkhoff's interpolation formula.

BEARING METALS

ALUMINUM-SILICON ALLOYS. Aluminum-Silicon Alloys as Piston Materials. Engineering v 133 n 3447 Feb 5 1932 p 172–3. Variations of Y-alloy type, sold as proprietary alloys, can be heat-treated, it is claimed, to give very high Brinell numbers; high-silicon aluminum alloys have excellent physical properties for use as piston materials, including high thermal conductivity lowest density of all commercia aluminum alloys, and low coefficient of linear expansion.

BRONZE. Effect of Casting Temperatures and of Additions of Iron on Bearing Bronze (Cu 80: Sn 10: Pb 10), C. E. Eggenschwiler.

U. S. Bur Standards—J Research v 8 n 1 Jan 1932 p 67–70 (discussion 70–7). Effect of different casting temperatures (1850 to 2120 F) and of additions of iron (from 0 to 1.0%) upon hardness of structure, and resistance to wear, to pounding, and to single-blow impact of bearing bronze containing 80 per cent copper, 10 per cent tin, and 10 per cent lead.

CHEMICAL ACTION OF LUBRICANTS. Tests on Tin-Base and Lead-Base Bearing Metals, C. Jakeman and G. Barr. Engineering v 133 n 3448 Feb 12 1932 p 200–2. Research carried out for Tin Research Sub-Committee of British Non-Ferrous Metals Research Assn with primary object of ascertaining comparative chemical action of lubricants; results show that, except in case of oils containing free fatty acid, chemical action upon any of bearing metals employed is of little importance.

CRYSTAL STRUCTURE. Bearing Metals, C. H. Bierbaum. Mimeographed Preprint of Metals and Alloys Conference at Case School of Applied Science Cleveland Ohio Nov 18–20 1931 4 p. Principal characteristics of bearing metals with particular regard to crystal structure.

BEARINGS

BALL MANUFACTURE. Ball Bearing Manufacture, W. Fish. Engineer v 153 n 3970 Feb 12 1932 p 181. Principal features are, great accuracy maintained in all dimensions of ball bearing, balls being correct to $^1/_{10,000}$ in.; before hardening, balls are rough-ground; manufacture of ball races and housings. Before Junior Instn Engrs.

CAR. See *Cars* (Bearings).

DESIGN. Der Lagerdruck bei schnellaufenden Maschinen, W. E. Baltz. Werkzeugmaschine v 36 n 3 Feb 15 1932 p 42–3. Effects of gyratory couples and bearing pressure in high-speed machinery illustrated by example of centrifuge.

NOMY TYPE. Nomy-Lagret, ett Nytt Radiallager Enligt Michellprincip, G. Wallgren. Teknisk Tidskrift v 62 n 3 Jan 16 1932 (Mekanik) p 1–11. Design and operating principles of Nomy bearing built according to Michell principle; features of self-alignment and lubrication.

BOILER FEEDWATER

HEATING. Calculating Unknown Factors in Feed-Heater Operation, J. W. Romig. Power v 75 n 10 Mar 8 1932 p 378–9 To make survey of low-pressure steam demands, feedwater-heater requirements must be measured or calculated so that deductions of its demand may be made; fundamental factors; methods of measurement; development of formulas; solution of typical problem; comparing methods of operation.

TREATMENT. Chlorine Treatment of River Water at Powerton Station, K. E. Stoll. Power v 75 n 5 Feb 2 1932 p 168–9. During period of year, chlorination of condenser cooling water has resulted in average gain in vacuum of 0.24 in. of mercury; gain of 0.06 in. pays for cost of operation and maintenance of system; no corrosive action has resulted and at no time has it been necessary to take condensers out of service for cleaning; diagramatic layout of permanent chlorination equipment; operating data.

BOILERS

DESIGN. Economical Relation Between Heating Surfaces of Boiler Plant and Its Working Steam Pressure, N. Yoshimizu. Soc Mech Engrs Japan—J v 33 n 4 Dec 1930 p 198–202. Thermodynamic method of calculating economical proportion of heating surfaces of boiler and most economical steam pressure. (In English.)

FURNACES, WATER-COOLED. Heat Absorption in Water-cooled Furnaces. Engineer v 153 n 3968 Jan 29 1932 p 119–20. In developing combustion steam generator, series of tables and charts were built up which would be available to those responsible for predetermining performance; work has been collected in volume of calculations, charts, and tables.

HIGH-PRESSURE. Die Umwaelzpumpe des Loeffler - Hochdruckkessels, B. Belohlavek. Waerme v 55 n 6 Feb 6 1932 p 81–6. Circulating pump of Loeffler high-pressure boiler; calculation of drive for steam pump; design of reciprocating and rotary pumps and results of practical experiences.

Indirectly-Heated Boiler at Bitterfeld. Elec Times v 81 n 2104 Feb 18 1932 p 214–15. Schmidt boiler, in which indirectly heated system is used, has been in commercial service since 1928 at works of I. G. Farbenindustrie at Bitterfeld and operates at 100 atm; operating experience over this period has been of considerable and has demonstrated commercial applicability of indirectly heated system for pressures exceeding 1000 lb per sq in.

Miniature Boiler Operates at 1,100 Deg. and 1,600 lb, D. Lewis. Power v 75 n 7 Feb 16 1932 p 238–40. Boiler with electrically heated superheater designed to deliver steam at 1600 lb pressure and 1250 F has been installed by Reading-Pratt & Cady Co., in research department of American Chain Co.; used for purpose of investigating steam valves and fittings for service at high temperatures and pressures; all-welded water-tube unit; design and constructional features; data of boiler tests.

MARINE-DESIGN. New Small-Tube Steam Generator Introduced to Marine Industry. Boiler Maker v 32 n 2 Feb 1932 p 26–9. Tests of new-type marine steam generator, developed by Foster Wheeler Corp, New York, indicated boiler efficiency in excess of 87 per cent steam-generation requirements call for normal steam production of 26,100 lb per hr with maximum requirements of 35,000 lb of steam per hr; operating pressure was given as 400 lb per sq in with final steam temperature of 750 F; details of design and construction.

NATURAL-GAS. Burning Natural Gas on Off-Peak Basis. Power v 75 n 6 Feb 9 1932 p 191–4. Stoker equipment in four different plants placed in storage or suitably protected to permit use of natural gas; oil used as standby fuel and in three of plants coal-fired; boiler retained to replace gas should supply be cut off; boiler performance over 10-day period with coal as fuel; comparative performance with natural gas; design, construction, and operating characteristics of natural-gas boilers.

TUBES—FAILURE. Une étude d'ensemble sur la résistance des materiaux a employer dans la construction des chaudières, G. Paris. Chaleur et Industrie v 13 n 141 Jan 1932 p 3–11. Summary study of strength of materials used in boiler construction and of causes of failure of superheater tubes, i.e., materials and manufacture guarantees; metallographic characteristics; metal corrosion; characteristics of tubes that failed; interpretation of results of study and conclusions.

BRASS

TERNARY. Der Einfluss von dritten Metallen auf die Konstitution der Messinglegierungen—IV, O. Bauer and M. Hansen. Zeit fuer Metallkunde v 24 n 1 Jan 1932 p 1–5. Fourth of series of investigations of influence of third metals on constitution of brass alloys; contribution to knowledge of ternary system Al-Zn-Cu; solidification of ternary alloys is analogous to that of binary systems; influence of aluminum on color and Brinell hardness of brass alloys.

CARS

BEARINGS—LUBRICATION. Railroad-Car Lubrication Tests. Ry Mech Engr v 106 n 2 Feb 1932 p 55–6 and 63. Standard Oil Co. of New Jersey is conducting series of tests with especially constructed machine; tests being run under wide range of temperatures; details of railroad car-journal oil-testing machines; features of testing room.

CONTAINERS FOR SHIPMENT. Pennsylvania Railroad Busy with Experiments on New Container Units, G. G. Wheat. Matls Handling and Distribution v 7 n 5 Feb 1932 p 24–5 and 52. Details of bottomless and sectional containers for handling brick; operating advantages.

CASE HARDENING

CARBURIZERS. Bewertung von Einsatzmitteln, H. Mueller. Maschinenbau v 11 n 3 Feb 4 1932 p 55–7. Methods of determining quality and costs of different types of carburizers; derivation of rating figure for eight carburizers illustrated by examples.

CASTINGS

SHRINKAGE. Method for Determining Volume Changes Occurring in Metals During Casting, C. M. Saeger, Jr and E. J. Ash. U. S. Bur Standards—J Research v 8 n 1 Jan 1932 p 37–56 (discussion) 57–60. Methods which have been proposed and used for determining various types of shrinkage undergone by cooling metal. Bibliography.

CHROMIUM STEEL

HEAT-RESISTING. Ein Beitrag zur Kenntnis hochhitzebestaendiger Chromstaehle, M. Schmidt and O. Jungwirth. Archiv fuer das Eisenhuettenwesen v 5 n 8 Feb 1932 p 419–26 and (discussion) 426. Contribution to study of heat-resisting chromium steels; requirements of heat-resisting steels; investigation of steels containing 22 and 30 per cent chromium with varying carbon content; determination of endurance at high temperatures and at room temperature; analysis of structure; influence of various heat-treating processes.

COAL HANDLING

PORTABLE EQUIPMENT. Portable Coal Handling and Weighing Plant. Engineering v 133 n 3446 Jan 29 1932 p 126–8. Plant manufactured by H. Simon, Ltd. can discharge either through manholes in jetty floor on to conveyor or into barges; weigher and its feed hopper are mounted on carriage which in turn is mounted upon runners; after passing through weigher, coal for barges is conveyed by tray into hopper o telescopic chute supported on cathead.

CONVEYORS

BELT. Use of Belt Conveyors for Storing Materials, F. Riedig. Mech Handling v 19 n 2 Feb 1932 p 55–6. In unloading of bulk goods at storage places, belt conveyors have in last few years been in increasing use; conveying processes described recently carried out by cranes and hoists; operating characteristics.

PHOTOELECTRIC CONTROL. Synchronizing Conveyors by Photocells and Selsyns, W. B. Snyder. Elec World v 99 n 7 Feb 13 1932 p 327. Features of control that synchronize delivering and receiving conveyors in steel plant in Youngstown, Ohio; equipment is so arranged that when two conveyors are synchronized properly, auxiliary field on pin-conveyor motor is deenergized; if conveyors move out of synchronism slightly, auxiliary field on pin-conveyor motor is energized in one direction or other.

COPPER

WELDING. Praxis der Kupferschweissung, E. Weese. Zeit fuer Metallkunde v 24 n 1 Jan 1932 p 11–15. Contribution to problem of copper welding practice; tensile strength and elongation of copper welds; repair of locomotive fireboxes; all-welded copper fireboxes; copper welding in chemical apparatus constructions; experiments with arc welding; influence of manganese on seam; investigation with X-ray analysis in repair works of German Government Railroads.

COPPER ALLOYS

BERYLLIUM-COPPER. Copper - beryllium "Bronzes," J. K. Smith. Am Inst Min and Met Engrs—Tech Pub n 465 mtg Feb 1932 14 p. Investigation to ascertain effect of varying percentages of beryllium upon pure copper and properties of resultant alloys in their softest condition, effect of heat hardening of them, and extent to which these properties could be augmented by different combinations of heat hardening and cold rolling. Bibliography.

COUPLINGS

FLEXIBLE. Shaft Alignment Tests. Engineering v 133 n 3446 Jan 29 1932 p 141. Account of recent tests made on small shafts fitted with flexible couplings and deliberately misaligned, carried out in United States; five types of coupling were used; test of British-American flexible coupling gave good results.

CRANES

TRAVELING. Der neue Haengekran, E. Roediger. Foerdertechnik und Frachtverkehr v 25 n 3 Feb 12 1932 p 33–6. New type of crane of Demag, Germany, not traveling on top of track, but suspended from it; by this arrangement crab moves freely below track, which solves many problems in handling.

CUTTING TOOLS

OPERATING ECONOMY. Pruefung der Wirtschaftlichkeit neuer Werkzeugstaehle zwecks Verbesserung der Werkstattleistung, Werner and Schuetz. Maschinenbau v 11 n 2 Jan 21 1932 p 33–7. Comparison of operating economy of different cutting tools and materials, particularly those used on lathes; tabulation of principal cost items for tool preparation, heat treatment, and maintenance; data on tungsten carbide and high-speed steel.

TESTING. Testing and Recording Performance of Small Tools, C. E. Greenawalt. Machy (N. Y.) v 38 n 6 Feb 1932 p 426–9. Methods of recording and interpretation of test results for drill and pneumatic chisel at plant of Westinghouse Electric and Mfg Co.

DIE-CASTING MACHINES

DEVELOPMENTS. Fortschritte im Spritzguss-Maschinenbau, A. Kaufmann. VDI Zeit v 76 n 5 Jan 30 1932 p 105–7. Development during last 5 yr of die-casting machines for aluminum, zinc, and brass castings, with particular regard to design by Madison Kipp Corp, Gebr, Eckert, Nuernberg, and H. Barthel, Schweinfurt; hydraulic and pneumatic operations.

DIE CASTINGS

COMBINED WITH STAMPINGS. Combining Die Castings with Stampings, L. H. Morin. Iron Age v 129 n 4 Jan 28 1932 p 286–7. Specific examples of combining die castings with stamp-

ings and field open to designers; combination details and uses.

DIES

PUNCHING. Designing Close-Fitting Die Sets for Punching Thin Stock, H. R. Schmidt. Machy (N. Y.) v 38 n 6 Feb 1932 p 412-4. Die set with guide pins fixed in punch holder to minimize shearing due to misalignment of ram; diagram showing how shearing of conventional die set occurs when punch is tilted by ram that is out of line.

DIESEL ENGINES

AUTOMOTIVE. Les véhicules industriels a moteur Diesel au XXVᵉ Salon de l'Automobile, G. Delanghe. Genie Civil v 100 n 3 and 4 Jan 16 1932 p 65-7 and Jan 23 p 90-3. Design of Diesel engines for commercial vehicles shown at 25th automobile exhibition; performance of Renault, Panhard, Unic, Berliet, Saurer, and Tatra; fuel injection equipment by R.E.F. and Bellem.

Reciprocating Sleeve in Claus Diesel Varies Cylinder Volume. Automotive Industries v 66 n 7 Feb 13 1932 p 223. Operating principles of Claus Diesel engine in which combustion is controlled by increasing combustion-chamber volume at beginning of power stroke by means of sleeve surrounding piston.

DESIGN. Double-Acting Diesel of Future, A. Craignon. Power v 75 n 9 Mar 1 1932 p 332-4. Conclusions by author concerning future possibilities of 2-stroke-cycle double-acting type of Diesel engine; comparative analysis of double-acting and single-acting types; installation of large Diesels for battleships; compromise engines.

Recent Developments in Compression-Ignition Engines, O. Wans. Brit Motor Ship v 12 n 143 Jan 1932 p 424; see also Mech World v 90 n 2347 Dec 25 1931 p 614-5. Engine of compression-ignition type is fast displacing air-injection or Diesel type; as outcome of higher piston speeds much investigation is given to surface hardness of material used for liners; centrifugally cast liner has good wearing properties; supercharging; camshaft drive. Before Instn Engrs-in-Charge.

Some New Observations on Measurement of Temperatures in Diesel Engines. Sulzer Tech Rev n 1 1932 p 10-14. Temperatures in Diesel engines may help to throw some light on processes taking place in cylinder, i.e., distribution of injection air; influence of speed; temperatures when starting and stopping; temperatures in starting and exhaust valves.

INDUSTRIAL POWER. Trends in Diesel Engines for Industrial Power, O. F. Allen. Power v 75 n 10 Mar 8 1932 p 363-5. Review of various American and European Diesels designed for industrial purposes; objective of design is smooth, quiet, and efficient operation; Diesel engine developments.

OPERATING COSTS. Diesel Engine Power Costs. Nat Elec Light Assn—Proc v 87 mtg June 16-20 1930 p 409-21. Report of General Power Committee, outlines method of determining cost of supplying power with Diesel engines, keeping in mind viewpoint of industrial-plant executives for whom cost comparisons usually are prepared. Bibliography.

PULVERIZED - FUEL. Der Kohlenstaubmotor Rupamotor. Progress Reports of der Kosmos G.m.b.H. Rud. Pawlikowski Goerlitzer Maschinenfabrik in Goerlitz (Schles.) 1931 28 p and supp papers figs diagrs tables. Progress reports on design and operating characteristics of 4-cycle engine built by Goerlitzer Maschinenfabrik in Goerlitz, with bore and stroke of 500 by 720 mm, developing 140 hp at 170 rpm; fuel consumption 0.275 kg lignite powder (1375 cal) per ihp-hr equivalent to thermal efficiency of 46%.

Pulverized Coal Diesel Engines. Brit Motor Ship v 12 n 144 Feb 1932 p 441. 140-bhp single-cylinder engine put through series of tests with different types of coal, with coal and oil mixed in varying proportions and with oil alone; cyl. diam. is 500 mm and stroke 720 mm; speed 165 rpm.

RATING STANDARDIZATION. Rating and Testing Compression-Ignition Engines, E. T. Vincent. Motive Power v 3 n 2 Feb 1932 p 7-10 and 33-4. After outlining factors upon which combustion process of compression-ignition engine depend and discussing some of phases of design, author states that fuel consumption, smoke, maximum pressure of combustion, overload capacity, and available fuels should receive major consideration in rating such engine, and presents further discussion of testing procedure and instrumentation.

STEARNS DIAMOND. Stearns Diamond Diesel Engine, J. Kuttner. Diesel Power v 10 n 2 Feb 1932 p 65-6. Details of 150 hp, 1500 rpm, 2-cycle, 8-cylinder Diesel engine developed by F. B. Stearns, of Cleveland, Ohio; bore 3¼ in., stroke 5 in., displacement 664 cu in.; weight 1800 lb; blower scavenging; sectional view of transmission and piston arrangement diagram.

SULZER. Sulzer Double-Acting Diesel Engine. Power Engr v 27 n 311 Feb 1932 p 61-5 and 74. Design, construction, and operating details of first commercial stationary double-acting Sulzer 2-stroke cycle engine; 10,800 bhp unit recently completed at Winterthur for La Maigrauge Power Station, Fribourg, Switzerland; diagram of fuel valve and injection-air pressure control; diagram of starting-valve control.

DISKS

PERIPHERALLY LOADED ROTATING. Disk Subjected to Many Compressive Loads in Its Periphery, Y. Takeda. Soc Mech Engrs Japan—J (Foreign Edition) v 33 n 4 Dec 1930 p 183-97. Theoretical analysis of case of disk subjected to any even number of loads; disk subjected to any odd number of loads; rotating disk with many concentrated masses. (In English.)

ELECTRIC FURNACES

ANNEALING. Elektrische Blankgluehoefen und ihre Nutzanwendung, H. Nathusius. VDE Fachberichte 1931 p 174-6 and (discussion) 176-7. Two new bright-annealing methods and furnaces developed by Brown Boveri Co., i.e., Gruenewald and Heddernheimer systems.

Le recuit des métaux au four electrique. J du Four Electrique v 41 n 1 Jan 1932 p 11-17. Annealing of metals in electric furnace; special furnaces for this purpose; those employed in plants of Siemens & Schuckert taken as example; blank annealing furnaces; finishing furnaces; choice of furnace.

NEW TYPES. New Electric Furnaces, E. F. Russ. Electrochem Soc—Preprint n 61-9 for mtg Apr 21-3 1932 p 109-13. Russ induction furnace successfully applied to large-scale melting of non-ferrous metals at decided saving in energy as compared with melting in small units; hearth-type furnaces for aluminum melting consumes 450 kwh per ton of metal; electric annealing in induction furnace commercially applied to copper and brass strip up to 120 cm wide and 3 mm thick.

ELECTRIC WELDING

ARC. Holding Down Costs in Production Arc Welding, R. Kraus. Am Mach v 76 n 4 Jan 28 1932 p 137-41. Cutting and fitting prior to welding; cleaning and grinding; use of different sizes of electrodes; Westinghouse Co practice of preventing stresses; various locations of ground lead to reduce blow; typical welding jigs and fixtures.

RESISTANCE. New Resistance Welding, M. L. Eckman. Welding Engr v 17 n 2 Feb 1932 p 42-4. Definitions and applications of spot welding and projection welding, seam welding or continuous line welding, and flash welding and butt welding; operation of machine built by Federal Machine and Welder Co., Warren, Ohio, for flash welding up to 140 bbl per hr. Before Seventh Annual Welding Conference, Purdue Univ.

Sixty 8-Inch Pipe Welds Per Hour, M. Clark. Welding Engr v 17 n 1 Jan 1932 p 29-31. Factors involved in design of modern heavy-duty flash welders to secure fast production and flexibility; performance data of hydraulically operated machines built by Taylor Winfield Corp., Warren, Ohio.

ELEVATORS

ELECTRIC—DOOR OPERATION. Photocell Controlled Elevator Doors, C. E. Ellis. Electronics v 4 n 2 Feb 1932 p 54-5. Application of photoelectric cell for opening and closing of doors at approach; practical hints on use of photocells in other safety applications.

EMPLOYMENT MANAGEMENT

TECHNICAL MEN, TURNOVER OF. Causes of Turnover of Technical Men, H. L. Horning. Soc Automotive Engrs J v 30 n 2 Feb 1932 p 98-100. Factors affecting continuation of employment; turnover a measure of management efficiency; causes of dissatisfaction among technical men.

FANS

SELECTION AND INSTALLATION. Selection and Installation of Ventilating Fans, C. L. Hubbard. South Power J v 50 n 2 Feb 1932 p 46-9. Facts concerning use of data, tables, and tests furnished by manufacturers of fans to aid engineer in choosing and installing such equipment; type, speed, hp requirements, drives, heads, and duct requirements are included.

FITS

TOLERANCES AND. Limits, Fits, and Allowances, R. Rodger. Flight v 23 p 1200 Dec 25 1931 (supp) p 1264f-1264g and v 24 1205 Jan 29 1932 (supp) p 96d-96g. Limits suggested as sound basis compatible with various requirements of design and production in aircraft construction; bolt holes; pin holes; rivet holes; bolts and nuts; screw threads; shackle pins; hinges; plate fittings; tubing; machined parts; ball bearings; castings; wheels and axles; power unit.

FLIGHT

BIRD. Safety Devices in Wings of Birds, R. R. Graham. Roy Aeronautical Soc—J v 36 n 253 Jan 1932 p 24-58. Analysis of peculiarity in flight of certain number of birds; separating wing-tip feathers in flapping and in gliding flight; possibility of applying some of lessons that birds can teach to design of flying machines, gliders in particular; bending and twisting of separated feathers; opening and closing of wing-tip slots; multi- and single-slot wing; relation between slots and shape of wings.

FLOW OF FLUIDS

MEASUREMENT. Der Staurost, ein neues Messgeraet mit geringem Druckabfall fuer Durchflussmessungen, E. Schmidt. VDI Zeit v 75 n 51 Dec 19 1931 p 1535-8. Description of new apparatus especially designed for measurement of discharge of liquids or gases flowing in conduits of circular or square cross-section; apparatus consists of series of parallel horizontal bars of streamline shape; apparatus is remarkable for low loss of head, which puts it in same class with venturi meters; length of apparatus is only 5 to 10 per cent of equivalent venturi.

FORGING

PRESSURE. Machining by Pressure, J. H. Friedman. Soc Automotive Engrs J v 30 n 2 Feb 1932 p 80-3. Advantageous applications of new type of pressure forging machine in making universal joints, connecting rods, valves, etc.; finish forging done on heat remaining from forging or annealing, at temperature below that at which scale is formed.

GAS TURBINES

HOLZWARTH. La turbine à gaz et ses réalisaeions actuelles, H. Veyssière. Science et Industrie v 16 n 216 Jan 1932 p 1-7. Thermodynamic principles of gas turbines, with data on 1100-hp Holzwarth turbine.

GEARS

BACKLASH. Minimizing Lost Motion in Mechanical Transmissions, W. M. Pohl. Product Eng v 3 n 1 Jan 1932 p 1-4. Method of analyzing backlash for each element of train, and its effect at driven end; examples illustrate reduction of lost motion in spur-gear trains by elimination of elements contributing to play.

EFFICIENCY. Modern Gear Efficiency Exceeds Limits Used in Most Designs, W. H. Himes. Machine Design v 4 n 2 Feb 1932 p 28-31. Factors controlling efficiency of gear transmission; chart showing worm efficiency for coefficient of friction of 0.03; relation of gear ratio to efficiency; spur or single or double helical gears in oil-tight cases; influence of speed and lubrication on efficiency.

POWER TRANSMITTING CAPACITY. Transmitting Capacity of Gears, W. Clough. Mech World v 91 n 2350 Jan 15 1932 p 54-5. Power transmitting capacity of gears determined by static and dynamic load; formula for calculating wear.

SELECTION. Practical Considerations in Gear Selection, W. H. Himes. Am Mach v 76 n 6 Feb 11 1932 p 197-9. Problem of choosing best of many types of gearing when speeds, ratios, and loads are unusual; parallel-shaft gearing; gearing with shafts at right angles (intersecting); gearing with shafts at right angles but in different planes (non-intersecting).

TESTING. New Gear Testing Instrument. Engineer v 153 n 3968 Jan 29 1932 p 138. Instrument, produced by D. Brown and Sons, is simple, and yet very accurate and reliable, mechanism for testing involute profile of teeth on spur and helical gears; capable of accommodating gears up to 12 in. in base-circle diam., and records directly on dial with sensitiveness to one ten-thousandth of an inch any deviations from correct involute form.

GRINDING

APPLICATIONS. Grinding Applications in Modern Manufacture, F. Horner. Machy (Lond) v 39 n 1006 Jan 21 1932 p 517-21. Surface grinding; cup-wheel grinding; adjustable column supports of Blanchard vertical-spindle surface grinder for leveling, also concave or convex grinding; arrangement of pantograph on Naumann profile grinder; pantograph mechanism employed on Atkins thread-grinding machine; tool and cutter grinding.

HAMMERS

DROP AND SWAGE. Neuzeitliche Fall- und Gesenkhaemmer in Gesenkschmieden, S. Weil. Stahl und Eisen v 52 n 6 Feb 11 1932 p 144–8. Modern drop and swage hammers; improvements in hammer design and accessories, as exemplified in recent designs of hammers manufactured by Eumuco A.G. fuer Maschinenbau, near Cologne, Germany.

HARDNESS TESTING

DEPTH OF CASE. Ueber die Bestimmung der Einsatztiefe bei im Einsatz Gehaerteten Werkstuecken, W. Melle. Werkstattstechnik v 26 n 2 Jan 15 1932 p 21–4. Determination of depth of case; critical review of Hessenmueller work; relation between Rockwell hardness and depth of case can be established for certain materials, carburizers, and quenching liquids.

HELICOPTERS

STABILITY OF. La stabilità degli elicotteri (Stability of Helicopters), U. deCaria. Aeronautica, v 5 n 7 July 1931 p 471–6. Relative merits of different methods of control with particular regard to means of balancing of reaction forces of lifting screw.

HIGH-SPEED STEEL

HEAT TREATMENT. Electric Annealing of High-Speed Steels, W. S. Scott. Iron Age v 129 n 6 Feb 11 1932 p 388–90. Outline of annealing process together with design and operating characteristics of pit-type electric furnace; two-point temperature-control recording chart.

Electric Hardening of High Speed Steel, A. G. Robiette. Iron and Steel Industry v 5 n 4 Jan 1932 p 171–7. Consideration of factors influencing heat treatment of high-speed steel in relation to type of plant used; heating to quenching temperature; effects of overheating; quenching; tempering; preheating furnaces; hardening furnaces; control of atmosphere; types of salt bath; induction salt baths.

VANADIUM CONTENT. Effect of Vanadium in High-Speed Steel, A. B. Kinzel and C. O. Burgess. Am Inst Min and Met Engrs—Tech Pub n 468 mtg Feb 1932 9 p. Vanadium improves cutting efficiency of 18 per cent tungsten, 4 per cent chromium steels, if carbon content is properly controlled; carbon should be increased 0.2 per cent for each 1 per cent increase in vanadium; 5 per cent vanadium with 1.5 per cent carbon appears satisfactory; vanadium and carbon, increased in proper ratio, improve cutting efficiency of cobalt high-speed steel.

HYDRAULIC DRIVES

DESIGN. Hydraulic Drives Must Incorporate Slippage Factor, C. Morey. Machine Design v 4 n 2 Feb 1932 p 35–9. Characteristics and limitations of hydraulic drive illustrated by application to machine tools, steering-gear mechanisms, and stokers; determination of factors of horsepower, gallons per minute, and pressure.

HYDRAULIC TURBINES

EFFICIENCY. Multiple Nozzle Control Improves Turbine Efficiency, J. D. Schmidt. Elec World v 99 n 5 Jan 30 1932 p 229–30. It would be advantageous to close primary after secondary starts to open and to make secondary nozzle area sufficient to carry whole load up to load corresponding to full secondary opening; this condition has been achieved in case of 40,000-kw turbine in Milwaukee plant of Consumers Power Co. by means of special device; comparative water rate curves for 35,000-kw turbine.

PITTING. Pitting of Hydraulic Turbine Runners, A. H. Myers. Elec World v 99 n 7 Feb 13 1932 p 328–9. Examples of installations that exhibit corrosion pits from spot oxidation and also from electrolytic action; causes of two phenomena and corrective measures adopted.

HYDROELECTRIC POWER PLANTS

DESIGN. Fortschritte im Bau von Wasserkrafthaeusern und ihren Nebenanlagen, E. Marquardt. Zentrallblatt der Bauverwaltung v 51 n 45–7 Nov 4 1931 p 660–5. Review of modern continental European practice in design of hydroelectric power plants as exemplified by recent installations in Germany, Sweden, etc; pumped-storage plants.

SWITZERLAND. Kraftwerk Waeggital, H. Leuch. Assn Suisse des Electriciens—Bul v 23 n 2 Jan 22 1932 p 25–49. Detailed account of design, construction, and five years operation of hydroelectric power plant developing 150,000 kw with head varying from 176 to 260 m; hydraulic structures, mechanical and electrical equipment; statistical data on generation and cost of power. Bibliography.

WASHINGTON. First Major Low-Head Power Plant in West—Rock Island, W. D. Shannon. Eng News-Rec v 108 n 7 Feb 18 1932 p 240–4. Design and construction of 250,000-hp Rock Island Development of Puget Sound Power & Light Co., utilizing maximum flow of 54,000 sec-ft, of Columbia River, at maximum head of 51 ft; propeller-type turbine runners with adjustable blades used on account of wide variations in head; hydrology; construction program; gates and control works; fish ladders.

INDUSTRIAL MANAGEMENT

BUDGET CONTROL. Perpetual Budget, E. O. Sommer. Factory and Indus Mgmt v 83 n 2 Feb 1932 p 64–5. Kaleidoscopic changes are instantly reflected in method of budgeting outlined; typical budget machine-hr rate sheet.

DEPRECIATION. Depreciation in Machine-Building Plants, T. B. Frank. Machy (N. Y.) v 38 n 6 Feb 1932 p 441–2. Study of factors pertaining to depreciation, particularly as it concerns manufacturer of machinery and tools; rates of depreciation computed to cover obsolescence.

FOUNDRY COST ACCOUNTING. Applying Variable Budget Control to Jobbing Plant, R. O. Flanders. Iron Age v 129 n 4 Jan 28 1932 p 275–9. Methods employed in solving cost finding and cost control problems in Blue Valley Foundry Co., Kansas City, Mo.; outline of variable budget control system together with statistical review of results; details and summary of operations of foundry for year ended Dec 31, 1931.

PRODUCTION CONTROL. Development and Application of Standards to Production Management, M. H. Clark. Taylor Soc—Bul v 16 n 6 Dec 1931 p 218–23 and (discussion) 223–30. Line of approach employed in manufacture of puddled wrought-iron products by Reading Iron Co., Reading Pa.; problems in manufacture of puddled wrought iron; industrial engineering; application of standards.

Flashing Facts Aids in New-Product Control, N. J. Bowne. Factory and Indus Mgmt v 83 n 2 Feb 1932 p 69–70. Review of records that play important part in tooling up for new product; grouping records for follow-up operations; photostats in production control.

Small Company Profits From Close Production Control, B. Finney. Iron Age v 129 n 8 Feb 25 1932 p 483–7. Experience of Stimpson Computing Scale Co., proof that small company as well as large one can profit from close control of production and from installation of standard cost system; benefits include large reduction in inventories, consolidation of departments resulting in increased efficiency, concentration of responsibilities, and ability of management to ascertain instantly profitable or unprofitable operation of any department.

SELLING. Market Analysis and Sales Control, C. M. Bigelow. Nat Assn Cost Accountants—Bul v 13 n 10 Jan 15 1932 p 659–80. Outline of plan for properly organizing distribution functions on scientific basis; forecasting sales; review of all factors connected with selling. Bibliography.

INDUSTRIAL RESEARCH

BUDGET CONTROL. Budgeting Research, H. N. Solakian. Research Laboratory Rec v 1 n 3 Feb 1932 p 89–91. Proper amount to be allowed for research and how to determine it; factors determining budget for maintaining research laboratory or organization.

EFFICIENCY OF. Is Research Efficient?—I, R. F. Wilder. Factory and Indus Mgmt v 83 n 2 Feb 1932 p 53–5. Lack of coordination between research, sales, and production may be largely charged to narrow conception of scope of market research; failure to coordinate results in specific hazards which vary with individual cases; review of outstanding hazards.

INSPECTION

ENGINEERING. Justification of Organized Engineering Inspection, W. P. Digby. Engineer v 153 n 3968 Jan 29 1932 p 118–9. Answers are made to following questions: what is meant by inspection; how it is effected; essential qualifications of efficient inspector; relations prevailing between inspector and his principals and inspector and works officials; is inspection justified in all cases.

INTERNAL-COMBUSTION ENGINES

DESIGN. Schwarz-Cycle Engine Differs From Otto Type. Automotive Industries v 66 n 4 Jan 23 1932 p 121–2. Operating principles and design of 4-cylinder engine of $3^{7}/_{8}$ by $4^{1}/_{4}$ in. bore and stroke, developing 42 hp at 2200 rpm; fuel consumption of 0.58 lb per hp-hr when operating on gasoline; step piston acts as compressor on down stroke injecting about 20 per cent of amount of air normally in cylinder charge under pressures of 150–175 lb per sq in.

N.E.L.A. REPORT. Oil and Gas Engines. Nat Elec Light Assn—Proc v 88 mtg June 8–12 1931 p 841–54. Prime Movers Committee Report on progress of internal-combustion engine, as prime mover, in mechanical and industrial arts; general description given of developments made to date, both in design and application. Bibliography.

[See also *Airplane Engines; Automobile Engines; Diesel Engines; Oil Engines.*]

LOCOMOTIVES

ALLOY-STEEL FRAMES. Welding and Heat Treating Alloy Steel Locomotive Frames, W. A. Newman and C. F. Pascoe. Iron Age v 129 n 2 and 4 Jan 14 1932 p 172–4 and Jan 28 p 284-5 and 300. Extensive investigation of ten different alloy steels; heats for meeting demands for stronger steels in locomotive frames; table of tension tests on cast-steel frames; effects of welding methods on alloy steel in locomotive frames; proper methods of heat treatment.

COMPOUND. Four-Cylinder Compound 2-8-2 Tank Engines With Water-Tube Boilers and Rotary Valves, F. W. Brewer. Locomotive v 38 n 474 Feb 15 1932 p 46–8. Details of Schneider & Cie's 2-8-2 tank engine, No. 15, as rebuilt in 1915; longitudinal section showing boiler and superheater; dimensions in constructional features.

DIESEL. 150 PS - Dieselgetriebelokomotive fuer Marokko, O. Stamm. VDI Zeit v 76 n 6 Feb 6 1932 p 137–8. Design of 150-hp locomotive with gear drive for Compagnie des Chemins de Fer in Marokko; gage 600 mm; pulling power 6150 kg in low gear.

DIESEL - ELECTRIC. Diesel - electric Locomotives for Siamese State Rys. Locomotive v 38 n 474 Feb 15 1932 p 42–3. Details of passenger rail motor car and Diesel-electric locomotive for express freight traffic; construction and operating characteristics.

New Diesel-Electric Locomotives for Argentina. Ry Gaz v 56 n 5 Jan 29 1932 p 144–6. Introduced for shunting services at Port of Rosario, locomotives represent joint product of three leading continental engineering firms; elevations and plan showing general arrangement; arrangement of main components; list of dimensions and specifications; control devices.

DESIGN—GREAT BRITAIN. Trend of British Express Locomotive Design, W. A. Tuplin. Engineer v 153 n 3969 Feb 5 1932 p 149–51. Chief development has been in direction of higher thermal efficiency; methods employed are: designing valves and valve gear so that engine can work at early cut-off; raising boiler pressure; consideration given to valves and valve gear, cylinder arrangements, boiler and firebox, and wheel arrangements.

HIGH-PRESSURE. Super-Pacific Locomotives, C. De F. Du Nord, France. Ry Gaz v 56 n 8 Feb 19 1932 p 244–5. Design and constructional details; cylinders; high-pressure, 17.32 by 25.98 in.; low-pressure, 24.41 by 27.17 in.; coupled wheels 6 ft $2^{3}/_{4}$ in.; boiler pressure, 246 lb per sq in.; maximum compound tractive effort, 37,840 lb; total engine wheelbase, 34 ft $2^{1}/_{4}$ in.; weight of engine in working order, 98.9 tons.

PERFORMANCE. Timken Locomotive Completes First 100,000 Miles of Service. Ry Age v 92 n 7 Feb 13 1932 p 274–82. Analysis and review of performance data developed by Timken experimental all-roller-bearing locomotive during 21 months of active service on 13 railroads; map of United States illustrating lines over which Timken locomotive has operated; tabular summary of all runs in passenger and freight service.

LUBRICATING GREASES

VISCOSITY. Flow of Petroleum Lubricating Greases—I, M. H. Arveson. Indus and Eng Chem v 24 n 1 Jan 1932 p 71–5. Viscometer which predetermines rate of shear and is especially designed for measuring flow characteristics of lubricants; apparent viscosity of greases decreases with increasing rates of shear in manner characteristic of particular soap used, approaching in limit value higher than, but of same order of magnitude as, oil in grease. Bibliography.

LUBRICATION

MACHINERY. Effect of Speed, Temperature and Pressure Upon Lubrication, A. F. Brewer. Power v 75 n 10 Mar 8 1932 p 357–9. Successful lubrication of machinery will not exist unless effects of speed, temperature, and pressure existing at point of application have been anticipated; reference made to various lubricating conditions in several types of machinery.

MACHINE DESIGN

WEAR. Influence of Design and Construction on Wear of Machine Parts, F. W. Shaw.

Machy (Lond) v 39 n 1006 Jan 21 1932 p 529–30. Effects of accuracy of design, distribution of load, durability of materials, etc., on wear.

MACHINE TOOLS

CLAMPING DEVICES. Clamping of Fragile Work in Air-Operated Chucks, R. S. Wilkinson. Mech World v 90 n 2346 Dec 18 1931 p 594–5. Use of air-operated chucks on automatic lathe; means of distributing pressure.

DESIGN. Rollende Schlittenfuehrungen im Werkzeugmaschinenbau, O. Lich. Werkzeugmaschine v 36 n 1 Jan 15 1932 p 6–8 and 10. Use of roller and needle bearings for reducing friction between gliding surfaces of machine tools.

Verlaengerung der Lebebsdauer von Werkzeugkegeln durch Zweckmaeszige Anwendung der Querkeilbefestigungen, U. Pirani. Werkstattstechnik v 26 n 3 Feb 1 1932 p 47–8. Increase of life of taper shanks by use of cotter keys; DIN tables of principal dimensions for Morse and metric taper.

HYDRAULIC DRIVE. Hydraulic Transmission and Machine Tools, T. E. Beacham. Instn Production Engrs—J v 10 n 10 Jan 1932 p 253–62 (discussion) 263–74. Details of modern hydraulic variable gear in which oil is used instead of water; brief historical review of self-contained hydraulic transmissions; application of hydraulic transmission to machine-tool feeds.

MALLEABLE-IRON CASTINGS

HIGH - STRENGTH. New Product Broadens Field for Malleable Castings, E. Touceda. Steel v 90 n 6 Feb 8 1932 p 36. Properties of special product of higher average ultimate strength and yield point than malleable iron, although ductility is lower than that of high-quality malleable iron, used for guard rails, bridge rails, and side stakes.

MANUFACTURE. Versuche ueber Herstellung von Temperrohguss im Brackelsbergofen unter Verwendung von HK-Sonderroheisen, M. Paschke and K. Lange. Giesserei v 19 n 3/4 Jan 22 1932 p 23–7. Results of tests relating to manufacture of malleable iron, making use of HK special pig iron; improvements in Brackelsberg pulverized-fuel rotary furnace and properties of products obtained; properties of special pig iron made by Luebeck blast-furnace works; melting tests.

MACHINERY

CONTROL. Safeguarding and Controlling Sequence Operations, R. H. Rogers. Elec World v 99 n 8 Feb 20 1932 p 372–5. Conveyors or process machines that operate on material in sequence must be safeguarded electrically so that if any one unit becomes incapable of taking its full quota, preceding machines will feed at lower rate or stop; machine processing material can be arranged to control output of preceding machine on basis of either quantity of material on hand or by motor load; examples of application.

MATERIALS HANDLING

MACHINE SHOPS. Synchronizing Handling With Machine Operations, J. A. Dorsner. Matls Handling and Distribution v 7 n 5 Feb 1932 p 21–3 and 77. Advantageous results of mechanical handling methods in machine shops; outline of specific machining operations.

MATERIALS TESTING

FATIGUE FRACTURES. Gesetzmaessigkeiten des Dauerbruchweges, A. Thum and H. Oschatz. VDI Zeit v 76 n 16 Feb 6 1932 p 132–4. Report From Materials Testing Institute of Darmstadt Institute of Technology on factors determining shape and path of fatigue fractures; comparison of observations with deductions based on Prandtl's membrane method and Hele-Shaw's method; methods of modifying path of fatigue fractures.

METALS

COLD WORKING. Cold Working of Metals, J. W. Berry. Instn Production Engrs—J v 10 n 10 Jan 1932 p 297–304 (discussion) 305–12. Review of following processes in cold working of metals: drawing, rolling, and raising; heat treatment; cold raising; double-action presswork.

On Change of Modulus of Rigidity in Different Metals Caused by Cold-Working, T. Kawai. Tohoku Imperial University—Science Reports v 20 n 5 Dec 1931 p 681–709. In aluminum and brass, rigidity always decreases by cold-working, in copper, iron and steel it decreases, till minimum is reached, after which amount of decrease diminishes, with increasing degree of cold-working, in nickel rigidity increases rapidly at first, but after reaching maximum, decreases gradually. (In English.)

CUTTING. Ueberblick ueber die Zerspanungsforschung, M. Kurrein. Werkstattstechnik v 26 n 3 and 4 Feb 1 1932 p 41–5 and Feb 15 p 64–6 1 supp plate. Interpretation of research results regarding chip formation, action of cutting edge, cutting angle, feeds and speeds, etc.; representation of stress distribution and changes in structure during deformation and cutting process.

DRAWING. Spanlose Formung der Metalle, G. Sachs. Stahl und Eisen v 52 n 5 Feb 4 1932 p 119–22. Review of four investigations on shaping of metals with special reference to metals drawing and stamping.

HARDENING. Die Ausscheidungehaertung und ihre Anwendungsmoeglichkeit, E. Dorgerloh. Maschinenbau v 11 n 1 Jan 7 1932 p 5–7. Interpretation of principal research work on precipitation hardening for ferrous and non-ferrous alloys; heat treating characteristics of copper, beryllium, titanium, molybdenum and manganese, chromium-nickel, and nickel-alloy steels.

TEMPERATURE EFFECT. Cold Treating Metallic Alloys, H. S. Rawdon. Metal Progress v 21 n 2 Feb 1932 p 29–33. Utilization of liquid air or dry ice for making expansion fits; retarding of phase changes in duralumin; effect of cold treatment with dry ice on properties of high nickel-chromium steels.

MILLING MACHINES

CUTTING PRESSURE. Beschreibung und Kritik der bisher veroeffentlichten Schnittdruck - Messeinrichtungen fuer Fraesmaschinen, F. Eisele. Maschinenbau v 11 n 2 Jan 21 1932 p 37–43. Critical comparison of design and operation of devices for measuring cutting pressure on milling machines with particular regard to three-component measurements.

MOLDING MACHINES

ELECTRIC. Magnetically-Operated Moulding Machine. Engineering v 133 n 3447 Feb 5 1932 p 169. Machine embodies novel principle, inasmuch as motor is eliminated, and current is employed instead to energize simple solenoid directly actuating pattern table; machine is of squeeze pattern, perfected by British Insulated Cables, Ltd.

MOTOR TRUCKS

ELECTRIC TRANSMISSION. Turrinelli Transmission for Road Vehicles. Engineering v 133 n 3448 Feb 12 1932 p 186–7. New chassis introduced by G. Turrinelli; power units and transmission are self-contained in rear axle or axles; system is equally applicable to battery vehicles or trolley buses; there is independent motor for each wheel.

NICKEL

WELDING. Die Nickelschweissung, C. Canzler. Zeit fuer Metallkunde v 24 n 1 Jan 1932 p 15–18. Contribution to problem of nickel welding; gas welding; influence of manganese; arcatom (atomic hydrogen) and arcogen welding; welding of monel metal; pressure welding; practical applications.

NITRIDATION

SHORTENED PROCESSES. Shortening Nitriding Process, J. J. Egan. Iron Age v 129 n 5 Feb 4 1932 p 344–6 and (discussion) 346. Outline of several modern nitriding methods by which appreciable cases with satisfactory hardness are produced in 4-hr cycles; process recommended by author, one in which mixture of ammonia and nitric oxide is used. Before Nat Metal Congress.

NOISE

MEASUREMENT. Geraeusche- und Laermmessungen, G. Bakos and S. Kagan. VDI Zeit v 76 n 7 Feb 13 1932 p 145–50. Report from Heinrich-Hertz Institute for Vibration Research, of Berlin-Charlottenburg, on methods and results of study of Berlin traffic noises made by Noise Abatement Committee of Verein Deutscher Ingenieure; objective and subjective methods; investigation of noise in Berlin Postal Savings Office.

Rapport sur les bruits et leur mesure, Chavasse. Société Française des Electriciens—Bul v 2 n 14 Feb 1932 p 151–81; see also Annales des Postes Télégraphes et Téléphones v 21 n 1 Jan 1932 p 15–46. Reports on noise and its measurement; acoustical definitions; measuring equipment of Barkhausen and Western Electric; physical study of acoustic field; speed measurements by Rayleigh disk; electromagnetic and electrostatic methods of pressure measurement, etc; conclusions.

OIL ENGINES

VIBRATIONS. Torsional Oscillations Occurring in Crank-Shafts, J. Brown, A. L. Mellanby and J. F. Shannon. Engineering v 133 n 3445 Jan 22 1932 p 116–7. Measurement of torsional oscillation; shop records; trials at sea. Appendix to Sixth Report of Marine Oil Engines Trials Committee, presented at Instn Mech Engrs.

PISTON RINGS

THICKNESS. Die Wandstaerke der Kolbenringe, H. Lemken. Automobiltechnische Zeit v 35 n 2 Jan 25 1932 p 44–8. Investigation of effects of thickness of piston rings with particular regard to cylinder wall pressure; graphs and tables illustrate pressure data for DIN standards.

PLASTICS

MACHINING. Machining of Laminated Plastic Materials, L. L. Howard. Plastics and Molded Products v 8 n 2 Feb 1932 p 79, 81, and 3. Simplicity of proper machining operations; band sawing, drilling, punching, turning, preheating stock, tapping, and threading.

PLATES

IMPACT ON. Studio teorico su alcuni elementi del fenomeno dell'urto dei proietti contro piastre, E. Bianco di S. Secondo. Rivista Marittima v 64 n 12 Dec 1931 p 285–311. Theoretical study of phenomena of impact of projectiles on plates; reference to "Laws of High-Speed Punching" by Tresidder and to work of Dumas; calculation of speed and duration of perforation.

RECTANGULAR, STRESSES IN. Plaques minces rectangulaires soumises à des forces variables, M. Sonier. Académie des Sciences—C R v 194 n 5 Feb 1 1932 p 436–9. Theoretical mathematical discussion of stresses in and deflection of thin rectangular plates freely supported along perimeter and subjected to variable forces.

Ueber die Knickung von rechteckigen Platten bei Schubbeanspruchung, S. Bergmann and H. Reissner. Zeit fuer Flugtechnik und Motorluftschiffahrt v 23 n 1 Jan 15 1932 p 6–12. Mathematical analysis of buckling phenomena in rectangular plates under shear stresses.

POWER PLANTS

EQUIPMENT. Equipment Review. Power v 75 n 8 Feb 23 1932 p 263–317. Motors, electrical and elevator equipment, oil filters, purifiers and lubricating systems, piping, valves and welding fittings, pumps for power plant and industrial uses, regulators and controllers, steam, oil and gas prime movers and auxiliaries, steam traps, welding machines, and accessories.

LOAD. Load-Duration Curve, A. G. Christie. Power v 75 n 7 Feb 16 1932 p 243–5. Trend in power-station development definitely toward means whereby more kw-hr can be secured per dollar of total cost; year-to-year picture of load building; generating peak load; increasing plant capacity.

PRESSURE REGULATORS

HYDRAULIC. Vereinfachung hydraulischer Feinregler, J. Mugler. Waerme v 55 n 6 Feb 6 1932 p 90–1. Possibilities of simplification and cost reduction of hydraulic precision regulators are suggested example of improved Arca furnace regulator made by Askania Works.

PRESSURE VESSELS

CHROMIUM - VANADIUM STEEL. Chrome-Vanadium Steel Pressure Vessels. Vancoram Rev v 3 n 1 Jan 1932 p 7–12. Physical properties and composition of chromium-vanadium steel used in construction of pressure vessels and tanks either forged or welded.

WELDING. Designing and Testing Welds in High-Pressure Vessels, W. Spraragen. Iron Age v 129 n 5 Feb 4 1932 p 340–3 and (adv sec) 30. Continued review of safe designs for head construction, discussing necessity for stress relief and outline of various approved methods of inspecting and testing welds; methods of insuring ductility in welded joints.

PUMPS

CENTRIFUGAL. Kreiselpumpen fuer heisses Wasser, C. Pfleiderer. VDI Zeit v 76 n 7 Feb 13 1932 p 157–60. Theory of and data for design of hot-water centrifugal pumps, taking into account compressibility of water at temperatures above 200 C.

RAIL MOTOR CARS

DIESEL. Diesel Rail Car, Donegal Railways. Ry Engr v 53 n 625 Feb 1932 p 54–5. Design, construction, and operating characteristics of 74-bhp Diesel rail car for 3-ft gage line; Diesel engine supplied by Norris, Henty & Gardners Ltd., of Patricroft, Manchester; car weighs 7 tons and seats 32; elevation of plan views.

DIESEL-ELECTRIC. New Diesel-Electric Rail Cars. Ry Engr v 53 n 624 Jan 1932 p 25–7.

First of three Diesel-electric rail cars built by Armstrong Whitworth about to be placed in service on L.N.E.R.; automatic control; list of principal specifications, layout of general arrangement, design and construction of power equipment.

Oil-Electric Rail Cars on Pamplona San Sebastian Railway. Engineer v 153 n 3968 Jan 29 1932 p 136. 200-bhp cars built by Clayton Wagons, Ltd., of Lincoln and engined by Beardmore's, are used to provide regular service of passenger trains between San Sebastian and Pamplona, each rail car hauling two trailers weighing 16 tons each.

GERMAN. Neuere Triebwagen mit Verbrennungsmotoren, M. Breuer. VDI Zeit v 76 n 4 Jan 23 1932 p 73–9. Design and performance of new types of rail motor cars with internal-combustion engines, with particular regard to equipment of German State Railroads.

SAWS

METAL-CUTTING. Neuzeitliche Verbesserungen auf dem Gebiete des Kaltkreissaegens, H. Hollaender. Maschinenbau v 10 n 19 Oct 1 1931 p 608–10. Modern improvements in circular cold saws; new features of representative German makes with particular regard to utilization of hydraulic feed mechanism; progress in standardization.

SCRAP METAL

BALING. Large Scrap Baling Press. Engineer v 153 n 3969 Feb 5 1932 p 162–4. Press by Rose, Downs, and Thompson, used for baling all classes of light iron and steel scrap, shearings, clippings, sheet iron, etc., up to 3/8 in. thick, as well as enameled iron and tinplate scrap, galvanized iron, etc.; output is from 10–18 tons per hr.

SPRINGS

POPPET-VALVE—DESIGN. Ueber die Ermittlung der erforderlichen Ventilfederkraft, E. Aster and P. Knechtel. Automobiltechnische Zeit v 35 n 1 and 2 Jan 10 1932 p 11–14 and Jan 25 p 49–51. Design of springs for poppet valves with particular regard to effects of different types of valve-lifting mechanisms, vibrations, etc.

STEAM

GENERATION. Steam Generation, F. Nicholls. Elec Rev v 110 n 2829 Feb 12 1932 p 223–4. Results of increased boiler output from given space in boiler house at Derby Corp. generation station; advance has been possible through increased efficiency of boiler heating surface; influence of radiant heating surface is indicated by rise in curve corresponding to recent additions giving more than 25 lb of steam per sq ft of total boiler heating surface.

HIGH-PRESSURE. Higher Steam Pressures and Temperatures. Nat Elec Light Assn—Proc v 87 mtg June 16–20 1930 p 1023–30. Prime Movers Committee Report discusses steam pressures exceeding 500 lb and temperatures above 750 F; pressure group may be divided into two parts, one embracing pressures up to 800 lb and other, from 1000 to 1500 lb and over; temperatures up to 750 F are in common use. Bibliography.

STEAM POWER PLANTS

HEAT LOSSES. Einfluss des Abgasverlustes auf die Wirtschaftlichkeit von Dampfkraftanlagen, O. F. Huettner. Waerme v 55 n 5 Jan 30 1932 p 65–8. Influence of exhaust-gas losses on economy of steam power plants; diagram in which phenomena are presented in such manner that waste-gas losses can be read in measurement unit, kilo-calories per kw-hr.

GREAT BRITAIN. Operating Results of Deptford West Generating Station. Engineering v 133 n 3445 and 3447 Jan 22 1932 p 89–91 and Feb 5 p 150–3 supp plates. Station on Thames River has pressure and temperature of 375 lb per sq in. and 780 F; both coal and coke used as fuel; 12 boilers are of Babcock cross-tube marine and Sterling tri-drum type with integral economizers; generating plant consists of two 25,000-kw sets and three 35,000-kw sets manufactured by British Thomson-Houston Co.

SMOKE ABATEMENT. "Flamma" Smoke Consumer. Engineer v 153 n 3967 Jan 22 1932 p 110. Device for destroying smoke produced in boiler furnaces, put upon market by Hartley, Sons and Co.; it depends for its action on admission, for adjustable period of time, of restricted amount of heated air to gases of combustion just after they pass from rear of furnace, result being that all smoke ignites to produce bright and heat-giving flame.

UNITED STATES. Glenwood Power Station No. 2, H. R. Barton. Elec Light and Power v 10 n 2 Feb 1932 p 18–23. Pulverized-fuel-burning plant, using storage system; steam pressure is 450 lb with total temperature of 800 F; generating voltage is 13,200 v which is stepped up to 66,000 v in outdoor switching station; all switching is done on h.t. side and all power is sent out at 66,000 v except for one 10,000-kva feeder to Glenwood Station No. 1.

STEAM TURBINES

BLADES. Erosion of Steam Turbine Blades, F. W. Gardner. Engineer v 153 n 3669, 3970, and 3971 Feb 5 1932 p 146–7 Feb 12 p 174–6, and Feb 19 p 202–5. Feb 5: Review of research work and development of method of protection which promises to provide means of controlling erosion and of ensuring reasonable life for exhaust end blades at highest speeds. Feb 12: Magnitude of forces involved; micrographs of characteristic erosion cavities. Feb 19: Experimental investigation; apparatus was constructed in which arrangement of actual turbine exhaust was reproduced; estimation of pressures produced on blade surface by impact of water drops.

50,000-KW SINGLE-SHAFT. 50,000-Kw Single Shaft Steam Turbine. Engineering v 133 n 3449 Feb 19 1932 p 234. Unit constructed by Brown, Boveri, and Co., Baden, runs at 3000 rpm; rated at 50,000 kw it is claimed to be largest single-shaft turbine yet built to run at speed stated; designed to operate with steam supplied at pressure of 781 lb per sq in. and temperature of 887 F.

N.E.L.A. REPORT. Turbines. Nat Elec Light Assn—Proc v 87 mtg June 16–20 1930 p 945–1022. Prime Movers Committee Report presents operating data for 276 turbine units, ranging in capacity from 20,000 to 160,000 kw, compiled for year 1929; data compared with similar data for years 1914 to 1928 inclusive and given in table.

STEAM RATES. Der Dampfverbrauch mehrstufiger Dampfturbinen, G. Forner. VDI Zeit v 76 n 5 Jan 30 1932 p 100–4. Development of new formulas for steam consumption of multi-stage turbines operating with condensation or back-pressure without bleeding.

WAUKEGAN, ILL., 115,000-KW UNIT. 115,000-kw Unit at Waukegan, R. O. Waltham. Elec Light and Power v 10 n 3 Mar 1932 p 17–21. At Public Service Co. of Northern Illinois, steam turbine-generator of 115,000-kw capacity at 95 per cent power factor, was placed in service at Waukegan station bringing capacity to 290,000 kw; turbine is 2-cylinder tandem-compound reaction type, with double-flow low-pressure cylinder; steam is withdrawn from high-pressure cylinder at about 200 lb pressure reheated to 750 F, and returned to high-pressure cylinder.

STEEL

ALLOY. See *Alloy Steels.*

CHROMIUM. See *Chromium Steel.*

COLD-WORKING. Steels for Cold Pressing, G. R. Bolsover. Staffordshire Iron and Steel Inst—Proc v 46 1930–31 p 17–35 and (discussion) 35–41 1 plate. Production of rimming steel; effects of cold working; brittleness following cold work; grain growth.

HEAT TREATMENT. Eigenspannungen bei der Waermebehandlung von Stahl, H. Buehler, H. Buchholtz, and E. H. Schulz. Archiv fuer das Eisenhuettenwesen v 5 n 8 Feb 1932 p 413–18 and (discussion) 418. Determination of longitudinal, tangential, and radial stresses in steel cylinders; influence of cooling speed, diameter of test piece, and carbon content on stress conditions, elimination of hardening and heat-treating stresses by tempering.

Thermal Treatment of Steels, W. R. Berry. Elecn v 108 n 2797 and 2802 Jan 8 1932 p 34–7 and Feb 12 p 215–18. Purpose of article is to assist engineers to better understanding principles underlying apparently simple thermal treatment processes, and their effects on design; factors controlling rate of cooling; relation of surface to mass; curves showing effect of tempering on physical properties of various hardened steels of same carbon content; properties tabulated.

HIGH-SPEED. See *High-Speed Steel.*

TANKS

WELDING. Automatic Arc Welding in Modern Tank Shop, R. B. Lincoln. Machy (N. Y.) v 38 n 6 Feb 1932 p 401–6. Production methods and equipment for welding of tanks for electric circuit breakers at East Pittsburgh plant of Westinghouse Electric and Mfg. Co.; use of welding machines.

TEXTILE MACHINERY

VIBRATIONS. Simple Measures Prevent Vibration in Textile Mills, C. L. Hubbard. Textile World v 81 n 7 Feb 13 1932 p 16–18. Practical review of constructional details for damping vibration to minimum.

THERMODYNAMICS

MIXED - VAPOR POWER GENERATION. Die Mischdampf - Krafterzeugung und der Widerspruch zum zweiten Hauptsatz, A Demski. VDI Zeit v 76 n 6 Feb 6 1932 p 135–6. Thermodynamic calculations disprove claim for higher efficiency of mixed-vapor power generation in reciprocating steam engines and steam turbines; numerical example for mixture of benzol vapor and steam.

TUBES

BRASS. Berechnung der Restspannungen in Kaltgezogenen Rohren, N. Dawidenkow. Zeit fuer Metallkunde v 24 n 2 Feb 1932 p 25–9. Detection of internal stress in cold drawn tubes; quantitative determination of stress (radial and longitudinal) in tubes by Kalakuzky, Heyn and Bauer, Sachs, Anderson and Fahlmann, and Fox; development of mathematical formulas for calculation of stress, based on author's method; application of formulas to stress measurements on brass tubes.

VIBRATIONS

MEASUREMENT Drei - Komponenten-Erschuetterungsmesser, R. Leonhardt. Bautechnik v 9 n 49 Nov 13 1931 p 704–5. Description of instrument, developed for Askaniawerke plant, measuring and registering all three components of movement of vibrating ground.

TORSIONAL. Torsional Vibration—How to Prevent It, D. B. Turcott. Product Eng v 3 n 2 Feb 1932 p 79–81. Rotating shafts that transmit or are subjected to periodic forces, as in milling machine and woodworking cutter-head spindles, might have excessive torsional vibration if not calculated to avoid resonance; practical review of necessary calculations for prevention of excessive vibration.

WAGES

MAN-RATING PLAN. Equitable Distribution of Wages by Man Rating, C. B. Gordy. Am Mach v 76 n 9 Mar 3 1932 p 306. Man rating plan of Oakland Motor Car Co. taking into consideration individual characteristics of workman.

WAGE-PAYMENT PLANS. Inter-Relationships of Wage Incentives, Standard Costs and Budgetary Control, C. W. Walkley. Nat Assn Cost Accountants—Bul v 13 n 11 Feb 1 1932 p 744–9. Factors involved in relation between wage incentives, standard costs, and budgetary control from viewpoint of major executive.

Non-Productive Workers Share in Norton Wage Plan, J. Geschelin. Automotive Industries v 66 n 6 Feb 6 1932 p 190–3. Plant layout rearranged and new equipment added to make incentives effective in Worcester (Mass.) factory of Norton Co.; formulas for earnings curves; results of new wage plan compared on basis of productive hours.

Story of Human Incentives—I and II, H. Haynes. Mill and Factory v 9 and 10 n 6 and 2 Dec 1931 p 27–9 and 75–9 and Feb 1932 p 25–8, 66, 8 and 70. Historical review of labor conditions; beginning of wage incentives; fundamental defects of scientific wage-incentive systems; five human accelerative principles.

WELDING

COPPER. See *Copper* (Welding).

ELECTRIC. See *Electric Welding.*

NICKEL. See *Nickel* (Welding).

PRESSURE VESSELS. See *Pressure Vessels.*

STRUCTURES, STEEL CASTINGS IN. Use of Steel Castings in Welded Structures, J. G. Ritter. Iron Age v 129 n 6 Feb 11 1932 p 396–8. Methods of combining steel castings with fabricated structures; review of factors determining selection of steel castings and welded construction in manufacture of electrical equipment; cost considerations. Before Steel Founders' Soc of Am.

TANKS. See *Tanks* (Welding).

WELDS

STRENGTH. Augmentation de la resistance aux chocs répétes des pièces assemblées par soudure, D. Rosenthal. Académie des Sciences—C R v 194 n 1 Jan 4 1932 p 56–8; see also Génie Civil v 52 n 4 Jan 23 1932 p 98. Review of German investigations and results of tests of welded joints of original design which showed high resistance to repeated impact.

STRESSES. Ueber die Kraftuebertragung in Flankenkehlnaehten, E. Kohl. Elektroschweissung v 2 n 8 Aug 1931 p 145–7. Study of design of welded joints based on stress distribution in side-fillet welds used for welding plates and bars.